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CONTENTS.

	Page
THE SARDINE OF CALIFORNIA—*Will F. Thompson*	193
HISTORICAL REVIEW OF THE CALIFORNIA SARDINE INDUSTRY—*Will F. Thompson*	195
FERTILIZER, STOCKFOOD AND OIL FROM SARDINE OFFAL—*W. L. Scofield*	207
METHODS OF SARDINE FISHING IN SOUTHERN CALIFORNIA—*E. Higgins and H. B. Holmes*	219
CALIFORNIA SARDINE FOOD PRODUCTS AND THEIR PREPARATION—*H. R. Beard*	238
INSPECTION IN THE SOUTHERN CALIFORNIA FISH CANNERIES—*Norman Hendrickson*	248
NOTES ON THE SEA LIONS—*E. C. Starks*	250
A DISTRIBUTIONAL NOTE ON HALIOTIS—*S. S. Berry*	254
A SELECTED BIBLIOGRAPHY OF CHEMICAL LITERATURE PERTAINING TO THE FISH INDUSTRY—*H. R. Beard*	256
EDITORIALS	261
FACTS OF CURRENT INTEREST	268
NOTES FROM THE STATE FISHERIES LABORATORY	268
REPORTS	271
VIOLATIONS OF FISH AND GAME LAWS	271
FISHERY PRODUCTS	272
SEIZURES	274
EXPENDITURES	274
INDEX	275

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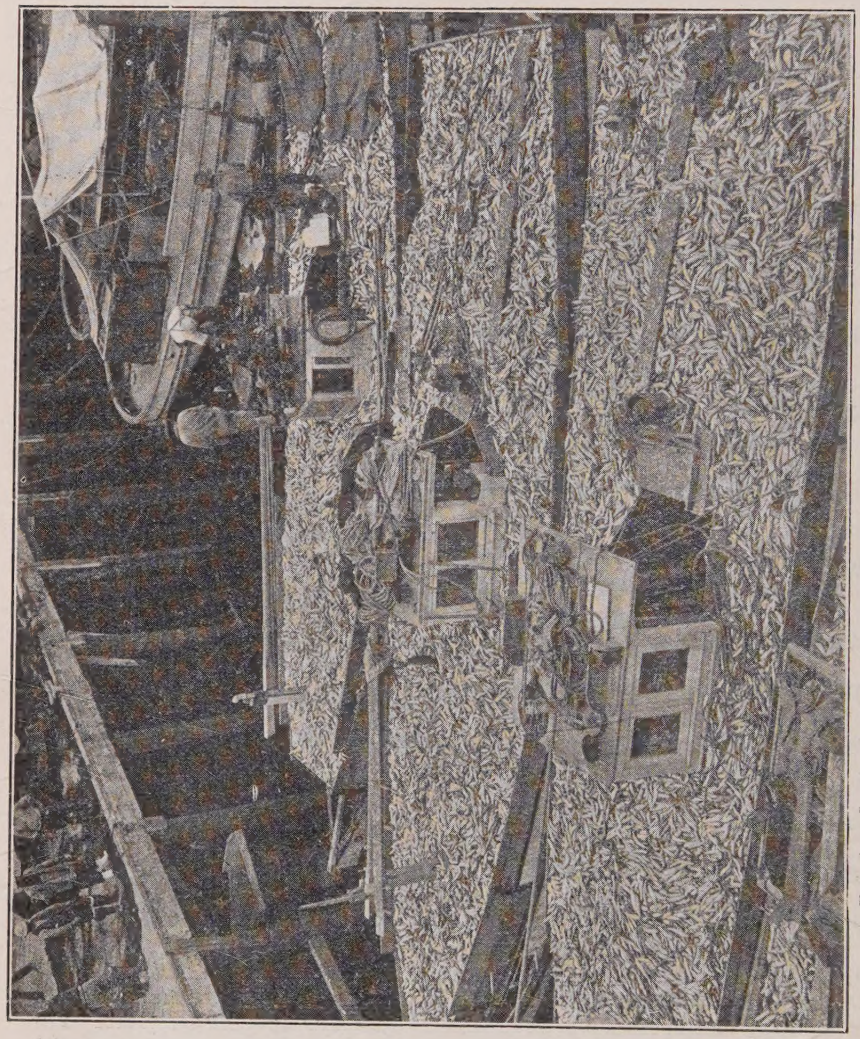


FIG. 54. Sardine boats waiting to unload, San Pedro. Photograph by E. M. Nielsen.

THE SARDINE OF CALIFORNIA.*

By Will F. Thompson.

In this number of California Fish and Game appear a series of articles upon the California sardine, dealing with the history of the fishery, the methods of catching, of canning, and the use of waste fish as fertilizer. They are not technical in nature, being designed for readers interested in fisheries in general, and do not attempt to speak authoritatively on debated points. The industry has been, for the past five years, an important one in California, and crucial years are ahead of it.

It should be understood, in the first place, that the sardine packed in California is a true sardine, in the sense understood by scientists of recognized standing.

This is not true of the "sardine" packed in Maine and other New England States. That is in reality a young herring, known to naturalists as *Clupea harengus*, whereas the true sardine is known as *Sardina pilchardus*. This herring is caught in great numbers along the Maine coast in weirs, or traps made in relatively shallow water. Its habits are different in many respects from those of the true sardine, for the eggs of the herring are laid on the sea bottom and attach themselves

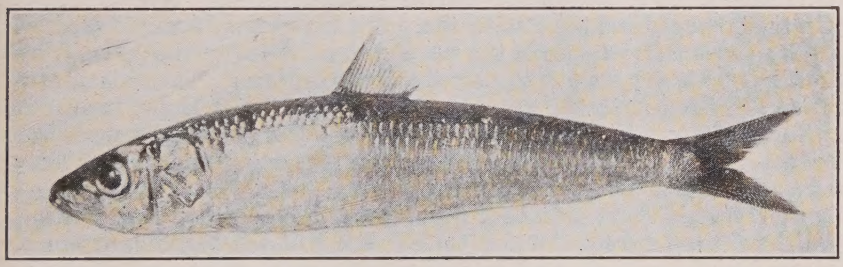


Fig. 55. The California sardine, a specimen without the usual spots. Photograph by H. B. Holmes.

there, while the eggs of the sardine are laid free in the water and drift with the currents. The differences in structure, flavor, etc., are equally marked.

The same remarks may be made about the Norwegian "sardines" save for the fact that among them one finds two species of fish widely different from the true sardine, namely the young of the herring, and the bristling, or young of the sprat, called *Clupea sprattus* by European writers. It is noteworthy that the English courts decided in 1916 that Norwegian fish packed as "sardines" could not be admitted into England under that name. According to the review of the court, bristling had been packed in oil in Norway since 1874, and they were at first called "Sproetten in oel," later "Sproetten a la Sardine," and finally "Norwegian sardines." The name sardine was therefore limited to the young of the pilchard, which are canned in France, Spain, Portugal and Italy as sardines. The pilchard itself is canned in Cornwall as pilchard. Later the Australian courts followed the example of the English.

*California State Fisheries Laboratory, No. 30.

The true sardine, or pilchard, is found from England along the Atlantic coast of Europe southward into the Mediterranean, and the adjacent coasts of Africa. It has been divided into two races, or varieties, the one found in the Atlantic and known as *Sardina pilchardus pilchardus,* the other found in the Mediterranean and known as *Sardina pilchardus sardina.* It still remains to be carefully investigated whether the difference between these two subspecies, or varieties, or races, is less than exists between some of the other "species" of sardine.

There are, indeed, throughout the world a number of these very closely related species of sardines. Thus there is the sardine of the Pacific Coast of America, from Alaska to Mexico, known as *Sardina coerulea,* and that of the coast of Peru, known as *Sardina sagax,* perhaps belonging to the same species, but more likely not. There is a gap of considerable extent between the extremes of their distributions, namely the tropical waters of the Gulf of Panama, and careful examination of many specimens will some time be necessary to determine their distinctness. Nevertheless, they both are extremely closely allied to the sardine or pilchard of Europe, in habits, distribution in the sea waters, movements and structure. This is granted by every competent authority. They are the only true sardines found in the waters of the Americas, save, perhaps, a species found occasionally in the West Indies, for no sardine is found on our Atlantic coast.

On the other side of the Pacific there are found the Japanese sardine, *Sardina melanosticta,* and the Australian *Sardina neopilchardus.* These are both very close to the European species. There is also a sardine to be found in the waters of the Cape of Good Hope, known as *Sardina ocellata.* The interrelationships of these various species are very poorly known and the morphological characters upon which they are based are insufficiently studied.

However, it is very plain that they are entitled to the name sardine, or pilchard, in contradistinction to the young of the herring, or sprat.

Regarding their habits and rate of growth, not a great deal is known. It is known that the eggs are pelagic, that is, laid so that they float freely in the open ocean waters, and that the adults in the waters of Europe and America disappear before spawning. Whether they are subject to the great fluctuations in abundance to which the herring is, still remains to be seen. The California Fish and Game Commission has collected careful data which it is hoped will in due time throw light on the subject of habits, rate of growth, migrations, and the presence of great changes in abundance. If the results which have been obtained in work on the herring can be paralleled, they will undoubtedly prove of much importance.

The following articles are regarded in no sense as a part of this work, although they do, to a certain extent provide a basis for judgment as to the changes which may occur in methods of fishing and canning in the future. This is especially true of the article on fishing gear and methods. An article by Professor Starks of Stanford University has appeared, in the April, 1918, number of CALIFORNIA FISH AND GAME upon the scientific characters of the members of the sardine and herring family found in the waters of California, and anyone interested is referred to that publication.

HISTORICAL REVIEW OF CALIFORNIA SARDINE INDUSTRY.*

By WILL F. THOMPSON.

The sardine industry in California is, as it now exists, essentially a product of the great war. Previous to its outbreak there had been a relatively small pack at Monterey and San Pedro, but the machinery for a vast expansion already existed in part in the tuna canneries of southern California. With the practical cessation of sardine imports into the United States in 1915, and the later great foreign demand, the pack of California sardines rose to great heights. Now with the coming of peace and the gradual return to normal conditions still so far removed, it remains to be seen how our new industry will meet competition. The development of fishing and packing methods have thus far been incidents only in the thorough upheaval of 1914, and the history to be here recorded gives little clue to how well fitted they are for survival. So, in a measure, this review is not a history, because it is written during the event.

Nevertheless, since the existence of methods, and a knowledge of the availability of the raw material, enabled the California sardine canners to so readily seize their great opportunity, the prewar period is of much interest. Failures and crudities naturally played their parts, as might have been expected, for a bodily transportation of fishing and canning methods from the great existing European and Maine fisheries was impossible. The California sardine is a true sardine, with vastly different habits than the young herring and sprat of the Maine and Norwegian fisheries. Where in Maine weirs may be employed, here nets must be used. And of course, the quality of the fish is also different, requiring different treatment. At the same time, the difference between French and American labor and physical conditions effectively precluded the introduction of French methods of canning save in a general way. It is highly to be regretted that even at the time of the outbreak of the war, cannery methods were still imperfect and that such packs as that of the round can had still to be tried.

THE PREWAR PERIOD.

The canneries.

The Golden Gate Packing Company of San Francisco was the first sardine cannery on the Pacific Coast. During 1890, 1891 and 1892 it put up 20,000 cases of sardines in quarter-pound cans of the usual type, 7000 cases of one-pound round cans, and 7000 of two-pound. But, so it was said, the appearance of the sardines was erratic, and this, combined with other causes, resulted in the sale of the machinery, and its shipment to San Pedro, where sardines were to be found more consistently.

There it was utilized by the Southern California Fish Company, managed by A. P. Halfhill. This concern continued to pack sardines in a limited way until 1909, but in the meantime, in 1906, it had begun packing tuna, and toward this its energies were principally directed

*California State Fisheries Laboratory, No. 31.

until 1916. Other canneries, such as the Lower California Fisheries Company, the Pacific Tuna Canning Company, and the Premier Packing Company, all of San Diego; the Halfhill Tuna Packing Company, the South Coast Canning Company, and the Los Angeles Tuna Canning Company, of Long Beach; and the Van Camp Sea Food Company and the White Star Tuna Packing Company of San Pedro, began operations on the tuna. So that in 1916 there were ten firms engaged in packing this fish in southern California, with a long winter season when no tuna were available while sardines were. These firms provided the first great pack of sardines.

In northern California no such parallel industry had prepared the way. But F. E. Booth had, in 1903, started a cannery at Monterey, and in 1906, the Monterey Fishing and Packing Company (later reorganized as the Pacific Fish Company) had established itself. Mr. Booth began in a small experimental way about 1902 in a shed on a back street in the town of Monterey. His real canning operations were begun in 1903 in a small building on the waterfront where his cannery now stands. He started with quarter-oils and a little later packed larger fish, calling them mackerel, to suit the market then existing. However, seven or eight years later, the federal government ruled that they would have to be labelled sardines. The early canning was done by the old method of hand flaking, drying in the sun, and hand soldering the cans. For the first three years there was not even a power winch for hoisting the fish from the boats to the cannery wharf. Fish were hoisted by hand, pulled up in baskets and carried in the same to the tank in the cannery. The pound oval pack which has become the specialty of the Monterey canneries was developed under these normal conditions, and was well established at the outbreak of the war. So here, although but two canneries awaited the great expansion of the industry, they were on a relatively firmer basis, in so far as the sardine was concerned. In 1916, not only were the two existing firms kept busy, but a number of new canneries were started.

The fishing methods.

But, in northern California there had also developed a successful method of fishing, which provided a more uniform and cheaper supply of fish. This successful method was the use of the lampara.*

There has been some controversy as to whether or not fishing before 1905 was done with a gill net, and whether this was carried on during the daylight or at night. Gill netting, at present, is done in a small way for bait and for the fresh fish market, and has been practiced thus for many years at Monterey. So it is possible that during the first year of experimenting the fish were supplied by the gill net fishermen.

However, from 1903 to 1905 a purse net was used for sardines, for the most part in the daytime, usually in the afternoon, but occasionally at night. The fish were located by seeing them jump at the surface or by seeing schools in the shallow water. The cannery (F. E. Booth) furnished the equipment and the fishermen worked by the month for wages.

*These notes regarding the lampara are those of Mr. W. L. Scofield, who kindly made inquiries regarding the matter at the writer's request.

Instead of the modern lighter the "Sacramento River seine boat" was used. It was a light, double-ended boat, carrying the net and the catch. The seine was circled by hand from the skiffs, pursed from the seine boat or the skiffs, and pulled up between the fishing launch and the seine boat. The catch was dipped out and into the seine boat, about as at present.

The net was made of one-inch mesh, from No. 6 cord, was twelve fathoms deep and two hundred long. There being no "bag," the fish were held by pursing the bottom by means of a rope run through rings. The net was extremely heavy because of the small mesh, and ten men were necessary. Hauls had to be made in shallow water, because the fish were almost sure to be frightened and to sink below the net if the water were deep enough. Fortunately the sardines could be found in shallow water a good part of the year.

As the capacity of the cannery was only about ten tons, but one crew of ten to twelve men under a captain was employed during the first three or four years. The fishermen often failed to obtain a supply, and in 1905, the captain, Pete Ferrante, with Booth's backing, sent to Tangier for a lampara net, essentially similar to the one described elsewhere in this volume. This net had a bag of fine mesh in which the fish were trapped before they could sink, and it was easier to haul because of the coarse mesh in the wings. The purse seine and the lampara were at first used together, one for the day, the other for the night fishing, but in 1906 the purse net was abandoned because more expensive. Other lamparas were patterned after this first one, which soon went to pieces, and of course many modifications have been made since. But the use of the lampara soon enabled the fishermen to catch sardines in deep water and at night, when they could be located by their phosphorescence. The result was a larger and more certain supply. It can not be doubted that the lampara has played a most important part in the establishment of the sardine industry on this coast.

In 1905 or 1906, the lampara was carried on the launch, and a barge substituted for the seine boat. Since then larger and larger launches have been used, with more powerful engines, just as in all other marine fisheries the methods of transportation have been steadily improved. The nets themselves have been deepened to fish more efficiently, and in southern California the type of net which the Japanese fishermen have modified from the lampara is thought by many to be a great advance.

THE WAR PERIOD.

Then, with two canneries packing sardines at Monterey, the tuna canneries awaiting a method of filling in the long winter season in southern California, and the methods of fishing already developed, there occurred the outbreak of the Great War in 1914. It altered the sardine industry on this coast as thoroughly and profoundly as it did any other industry. First, in 1915, the domestic market was abandoned by the foreign packers to our own Maine and California industry, imports dropping sharply and continuously. Then, in 1917 and 1918, the European markets themselves were opened to our products by the derangements of supply, etc., in Europe, while with our entry into the war came the insistent campaign for food conservation, including the

eating of fish rather than meat. The effect of foreign conditions upon our imports of "fish packed in oil" and our exports of "canned fish except salmon" is shown in Figure 56, taken from the reports of the Department of Commerce of the United States. This illustrates this point well, since sardines form the bulk of both categories. It will be noted that imports declined in 1915, but that exports did not rise until later.

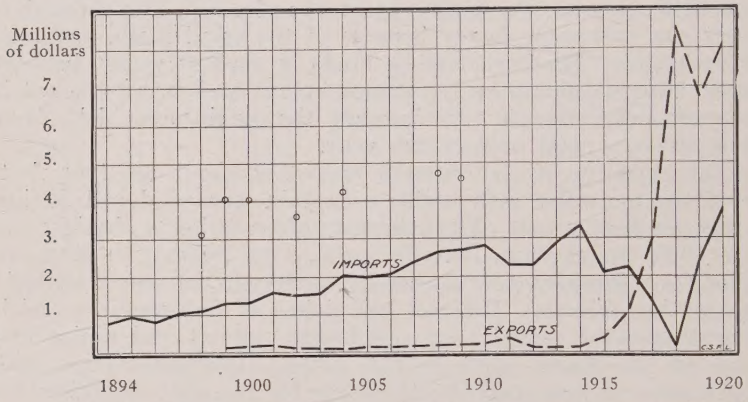


FIG. 56. United States imports and exports, to show condition of foreign trade. Imports of "fish (except shell-fish) packed in oil," and exports of "canned fish except salmon," as given by Monthly Summaries of Foreign Commerce of the United States, issued by Bureau of Commerce. Total value of Maine pack of sardines for various pre-war years shown as circles.

Foreign conditions.

To understand this change, however, the condition of affairs in Europe must be analyzed, and we may briefly review the history of the fisheries at Stavanger, Norway, where the packing of the Norwegian "sardine" is extensively done. In the lower part of Figure 57 are shown the exports to the United States. It is obvious that the fall is entirely parallel to that shown by Figure 56 for the imports into the United States, and that it was a fall of identical character in quantity as well as in value. However, in Figure 57, the middle section shows that the total quantity packed did not fall until a year or perhaps two years later, and that the value of the packed fish did not fall until three years later, namely, in 1917. In other words, the market for Norwegian sardines was found in Europe during the first years of the war, just as trade reports also indicate that better prices were obtainable in the British and German markets than in the United States. This condition prevailed during 1915, and also to an even more marked degree during 1916, a year termed by the Norwegians the "golden year" because of the high prices, and despite the rise in cost of materials and labor. But in 1917 and 1918 the exports to the United States and the total production both fell, because of scarcity of materials such as tin plate, olive oil, fuel oil, the prevalence of labor troubles, influenza and the placing of embargoes by belligerent countries. In 1917, for instance, there was a marked shortage of tin plate, save where the factories supplying goods to Germany were provided with cans by that

country. These conditions continued and were intensified during 1918, so that, in contrast to 1916, it was termed a "dead" year.

The effect of such changes as they affected the Norwegian canneries is, in passing, of great interest to us, as perhaps such changes as occurred to them may be apparent in the case of our own industry. The first result of the increase in price obtained was the founding of more canneries in 1916, and the later closure of many. Then there was

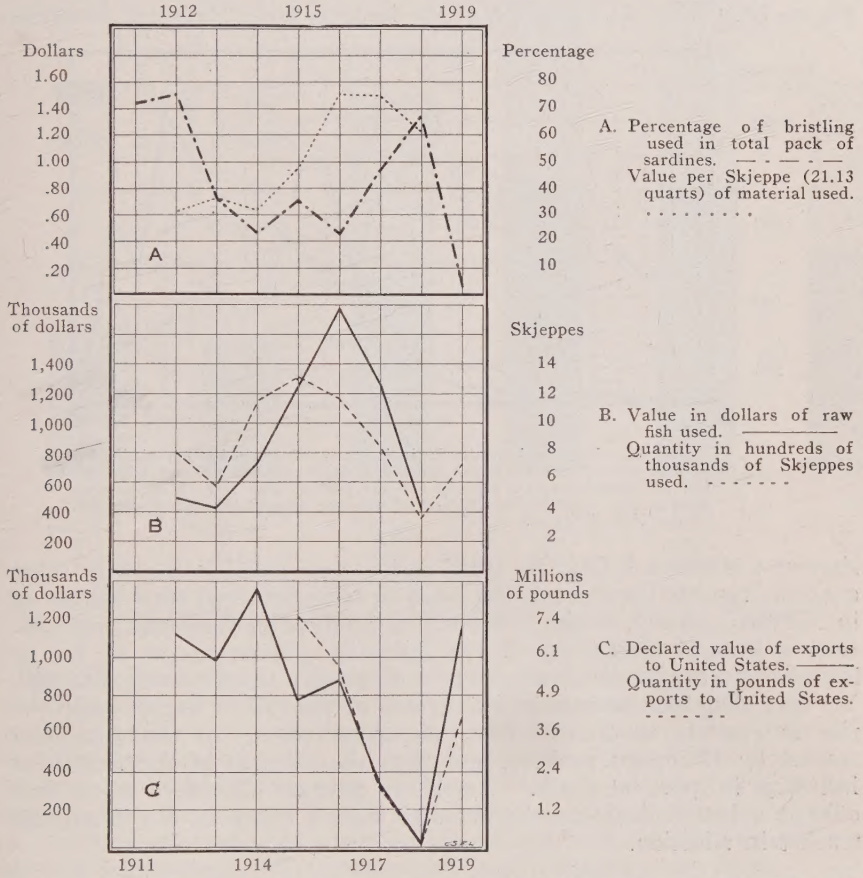


FIG. 57. Condition of sardine fishery at Stavanger, Norway. Data from Supplement to Commerce Reports, Bureau of Foreign and Domestic Commerce.

the increased value per unit quantity of fish used, apparently not dependent upon the composition of the catch. Thus in the upper section of Figure 57, the percentage—among the total of herring and sprat—of bristling, or young sprat, which are supposed to provide the best pack of "sardines," is shown by the line of dots and dashes. It is obvious therefrom that the largest part of the war pack was made from the young herring and the blending, or mixture of sprats and herrings, and that not until the very small pack of 1918 did the percentage of bristling rise. And that very promptly fell upon the

resumption of packing and export to the United States in 1919. But the value of raw fish per "skjeppe"* rose and fell in accordance with the value of the total. In other words, the war market was flooded with the pack of herrings and blanding, while the number of canneries first increased and then diminished.

That some such conditions applied throughout Europe would seem to be true from the fluctuations which occurred in the importations from various countries into the United States. These are shown in Figure 58. With the exception of the imports from Italy, all countries

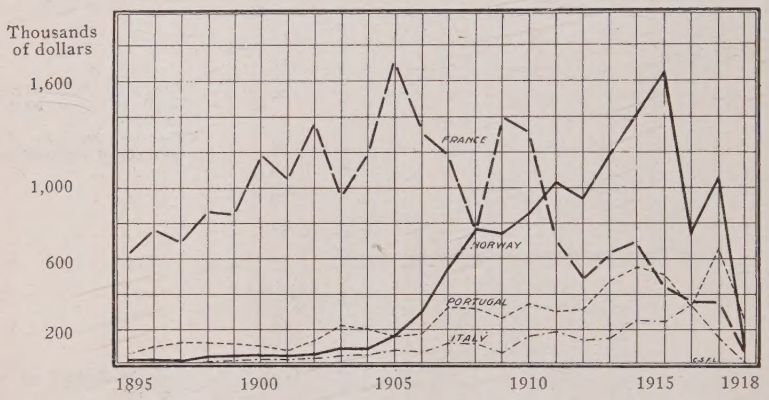


FIG. 58. Imports into the United States of "fish (except shell-fish) packed in oil," from various countries, showing rise of Norwegian and fall of French imports during pre-war period, also fall of all imports during war. Data from Bureau of Foreign Commerce and Navigation of the United States.

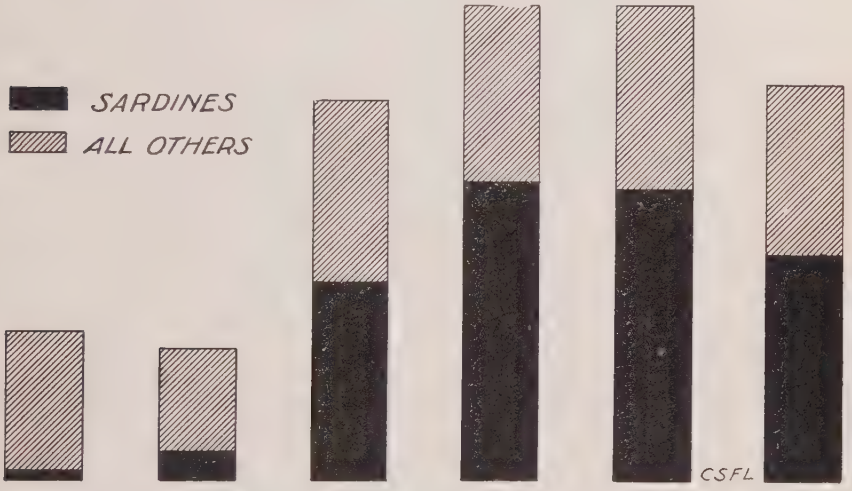
showed a decreased total in 1916, and a near collapse in 1918. Our consular reports show much the same to have occurred in Portugal as in Norway, namely, a first diversion of produce to European markets, then a general slackening of the industry, producing, in so far as imports into the United States were concerned, a nearly continuous fall. We may therefore summarize the causes of the fall in imports and the rise in exports as due to, first, the abandonment of the American market by European packers, and then the collapse of the European industry in part at least. American packers therefore were first offered a better domestic market and then a share in the European market in addition.

The rise of the California industry.

It will be seen that the most favorable conditions existed for our sardine fisheries, and the resultant effect upon the extent of our pack may be seen in Figure 59. Almost all sardines which are taken in this country are packed, and the increase in pack is clearly shown. The first great pack was, it is obvious, in 1917. And this corresponds with the great rise in value of sardines in this country, resultant in part from the conditions we have dealt with above, and in part from war conditions considered more generally in their effect on the domestic markets. At the same time we must remember the great encouragement

*A skjeppe equals 21.13 quarts.

given to the use of fish during 1917 and 1918 after our entry into the war. In Figure 60, we have shown the rise in value of Maine, Norwegian, Portuguese and French sardines in so far as they were obtainable in the Los Angeles markets, utilizing quotations on cases of a hundred quarter-pound oil sardines. When it is borne in mind that the California sardines were packed to meet the high values of 1917 and 1918, Figure 59 should be clearly understood.



	1915 millions	1916 millions	1917 millions	1918 millions	1919 millions	1920 millions
rdines	4	16	104	158	154	119
fish	78	70	200	250	250	208

FIG. 59. Catch of sardines in millions of pounds, compared with catch of all fish in California during period. Data from reports of California Fish and Game Commission, save for 1915, which is from orts of the Federal Bureau of Fisheries.

The rise in value is shown in Figure 60 on a logarithmic scale, which has the effect of making the rise of each commodity show as it would if reduced to a percentage basis, and the slope of the lines is therefore comparable and truly indicative of the relative rise in value. An increase of a dollar a case of Maine sardines would plainly be a larger proportionate rise than a dollar a case of French sardines, yet the ordinary charts would show the two increases as identical amounts, but the logarithmic chart shows them as considered in relation to the first price, namely, a greater rise for the Maine than for the French in proportion. The figure demonstrates that the Norwegian sardine did not rise as fast as the Portuguese, save for a brief period in 1920, and that the Maine sardine fluctuated in price much as did the Norwegian. In so far as the French sardine is concerned, the sudden rise in price in 1914 and the subsequent practical disappearance we have not been able to analyze. We have no data on the California pack of quarter oil sardines which is comparable to these shown, because such a pack was not placed on the market until 1917. But there are shown the changes in value of Booth's Crescent one-pound oval pack, from

Monterey, and this shows much less relative rise than the others utilized below.

Just as the first flush of war prosperity and high prices in Norway in 1915 and 1916 resulted in the starting of eighteen new canneries, so in California the tuna canneries turned suddenly to sardines and

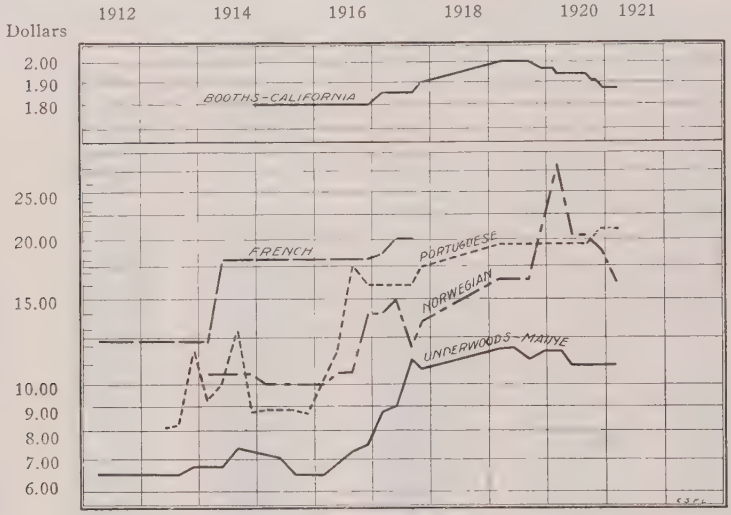


Fig. 60. Fluctuations in wholesale price per case of quarter-pound-oil sardines in Los Angeles during and shortly before the war. Above, price per dozen of Booth's Crescent, pound oval size. Given on logarithmic scale to show relative rather than absolute fluctuations in price. Data from Commercial Bulletin of Los Angeles.

new ones were constructed. To illustrate this point, we have attempted to tabulate the canneries and the time of their construction or diversion to sardine packing, according to the year, with the following results:

1894— 1 cannery built.
1903— 1 cannery built.
1906— 1 cannery built.
1915— 1 cannery built.
1916—14 canneries start packing, 11 previously tuna.
1917—11 canneries built.
1918—10 canneries built.
1919— 5 canneries built.
1920— 2 canneries built.

Of course, some of these are no longer existent or have ceased operations, but the point we desire to make is obvious, that there was a very considerable increase in canneries due to the value of the canneries, both for Monterey and for southern California, as contrasted with the much more modest rise in the pack produced, especially in southern California. It will be remembered that somewhat the same sequence of events occurred in Maine, when during the early days of the industry the canneries multiplied faster than the pack increased, until consolidation and elimination took place.

But there was another parallel with the Norwegian pack perhaps not less important, although perhaps not due to the same causes. And that was the emphasis upon quantity rather than quality. Previous to the outbreak of the war the pound oval held the field, but for a time the round can cooked inverted and by steam took a very prominent

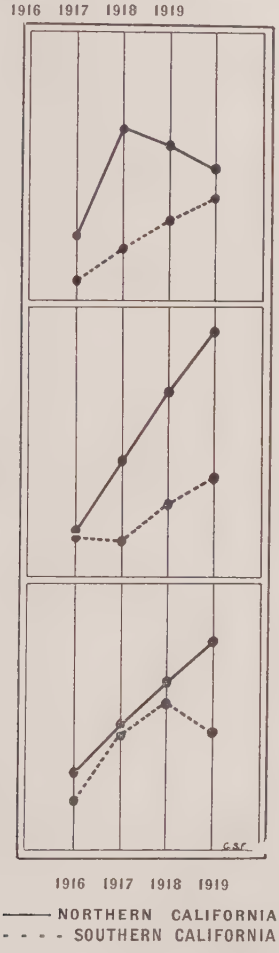


FIG. 61. Comparison of number of cases canned, value of packing plants and number of employees.

ALL FISH CANNED IN CALIFORNIA BY CASES

	Northern	Southern
1916__	196,104	522,609
1917__	480,111	1,538,122
1918__	729,100	1,385,202
1919__	905,206	1,166,435

VALUE OF FISH PACKING PLANTS

	Northern	Southern
1916__	$860,590	$948,702
1917__	786,197	2,573,453
1918__	1,569,330	4,089,660
1919__	2,272,514	5,436,357

NUMBER OF EMPLOYEES IN FISH PACKING PLANTS

	Northern	Southern
1916__	1,573	2,289
1917__	3,090	3,261
1918__	3,829	4,210
1919__	3,123	5,119

place. Introduced in 1916 by the Van Camp Sea Food Company, and widely adopted, this round can pack proved economical, and large amounts were shipped to Europe. But due to the emphasis upon quantity production its reputation was entirely lost. Other packs were subject to the same criticism, and far-sighted canners and brokers began to insist upon quality, foreseeing the failure of their markets under the more normal conditions sure to return in time. The National Canners' Association was asked to establish an inspection service and in 1917

this was done, as is related in another part of this issue. Under the stress of our entry into the war, the government for a time put the whole force of its influence back of this inspection service, in addition to a campaign of price fixing. At present the majority of southern California packers belong to it.

By-products.

An interesting part of the war demand was the high prices paid for oil, for fertilizer and for fish meal. Many of the canneries installed plants of their own for handling their offal, producing therefrom oil, and fish meal. But ultimately so much whole fish was diverted to these plants when the profit was greatest that the matter became serious and attracted attention. The California legislature therefore passed a law in 1919 placing the control of the matter in the hands of the Fish and Game Commission. The effect was to decidedly reduce the percentage of fish diverted to this use, but in 1920 the market for such by-products had in part declined so that there was less temptation to utilize fish for that purpose specially.

Competition within the state.

The three canning districts of Monterey, San Pedro and San Diego have to a certain extent competed with each other in the past, and the history of this is interesting, although only brief analysis of this can be made. There existed, previous to the war demand, two successful sardine canneries at Monterey, packing the larger sized sardines so readily obtained there. But the single sardine cannery in the south after intermittent operations finally turned exclusively to tuna packing.

The seemingly superior vitality and success during the prewar period of the Monterey packers may have been due in part to the greater ease of fishing in Monterey Bay, with the resultant cheapness yet excellent condition of the supply of raw fish, and the use of a larger, more economical type of pack than the quarter-pound square cans of the imported brands. It is said that the larger type of pack finds its principal market in such countries as Cuba and the Philippines, as well as the United States. How far foreign sardines are able to compete for this market we have not ascertained. But it may well be that an essential element in the history of the southern and northern packers has been the greater reliance of the former upon goods fitted for export and for competition with foreign brands.

The following table illustrates the differing styles of pack made in northern and southern California, due to the larger fish which prevail at Monterey. It is said that occasionally there is a year when sizes of fish suitable for quarter-oil packs are present at Monterey in numbers sufficient to render them easily caught, but that does not seem to be often enough to establish a quarter-oil pack there:

Sardine Pack in Three Statistical Districts, According to Percentage Packed in Various Sized Cans.

District	Quarter pound, per cent	Half pound, per cent	One pound, per cent
San Diego	55.5	17.9	26.6
San Pedro	16.7	37.8	45.6
Monterey	.8	2.8	96.3

It will be seen from this table that the Monterey district has packed more of the pound sizes, while the San Diego packers have depended very largely on the small sized fish for quarter-pound cans. Whether this will explain the greater steadiness of the price, as shown for Booth's sardines (Monterey) in Figure 60, and of the quantity packed as shown in Figure 62, we do not venture to express a decided opinion.

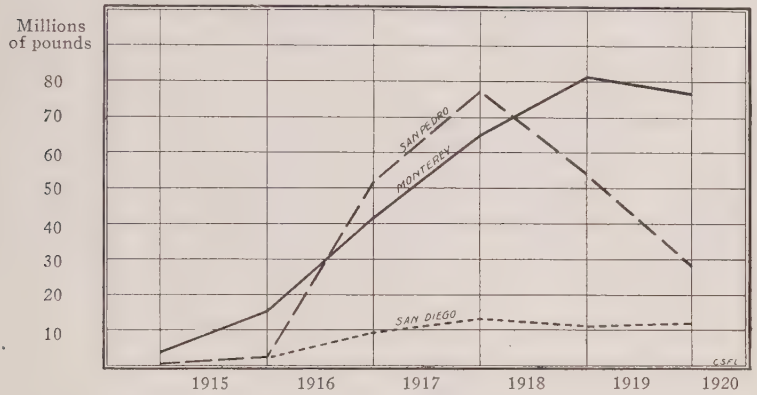


FIG. 62. Catch of sardines in three statistical districts of California. Data from California Fish and Game Commission, save for 1915, which is from Federal Bureau of Fisheries. (Note that pack of San Diego sardines is largely the valuable smaller sizes, and of Monterey of larger sizes.)

(Figure 62 shows the relative amounts packed in the three principal sardine districts of California.) This characteristic of the Monterey pack was shown also in 1915. At all events it would seem that the problem of maintaining the sardine industry in competition with foreign and Maine sardines more largely concerns the southern packers than the northern.*

It will be seen that we have not considered in detail the effect of the Maine sardine pack, as we have not yet material which bears upon the matter. But that the competition from Maine may be serious is easily ascertained from the figures for past production, in so far as we have them. In Figure 56, we have shown the pack value of Maine sardines as isolated circles for those years for which data are available.

Nor have we dealt with the appearance of the sardine, or rather the adult called a pilchard, in British Columbia. The salmon canneries there packed in 1917 a total of $11,810 worth, in 1918, $413,853, and in 1919, $371,871. These were sold as pilchards, according to the

*NOTE.—In so far as foreign competition is concerned, southern canners have recently expressed considerable concern over the effect of the rate of exchange upon the selling price of Norwegian sardines in this country.

As has been said by an official of a San Pedro corporation, with all foreign exchange at a low level, the tariff on canned fish no longer gives any protection, and Norwegian sardines are being sold to jobbers at $9.75 a case. Pacific Coast canners are compelled to ask $12 a case to pack. The Norwegian canner gets in his own money what is under normal conditions the equivalent of $20.20 for this $9.75.

This is, of course an aftermath which might have been expected from the changes in the rate of exchange, and the low level maintained by the disturbed conditions of Europe. It is one of those evidences of the desirability of restoring conditions in central Europe which are coming to light in increasing numbers.

English style of terminology. It yet remains to be seen whether the run was sporadic or not.

And, finally, we may add that it has not been our intention to in any way indicate an opinion of the future, for there is little of positive value in prophesying. Yet one may surmise that the increase of population in this country would of itself greatly enlarge the markets. From 1900 to 1910 the inhabitants of the United States increased about 21 per cent, while from 1910 to 1920 the increase was about 14 per cent. Yet the consumption of sardines, including the "fish packed in oil" and imported, increased over 40 per cent from 1900 to 1910, taking value as a criterion. The emphasis during the war upon the eating of fish could not help but have benefited the sardine industries. And added to these favorable facts, one may bear in mind the depletion in part of the salmon fisheries, and the general high cost of other foods. Indeed, despite the distinct evidence that war conditions had much to do with the birth of our sardine industry an optimist might find much to comfort him.

FERTILIZER, STOCKFOOD AND OIL FROM SARDINE OFFAL.*

By W. L. Scofield.

Introductory.

Although the fishing industry in California is new and by no means fully developed it is duplicating the experience of older industries and is giving more attention to the development of by-products. Of the hundreds of tons of fish caught in California each year, less than three quarters can be used for human food because over 25 per cent of the weight of fish is inedible. In our leading fishery industry, the canning of sardines, about 50 per cent of the catch goes into cans and roughly 50 per cent of the original weight is discarded as heads, entrails and broken and under sized fish. In mild curing king salmon, about one third of the original weight is lost in head, intestines, and backbone. In the past this great quantity of inedible fish material was thrown away as a complete loss. First in Europe and later in America this discarded material was found to be valuable and its conversion into a usable form proved to be financially profitable. A California sardine packer states that the profit derived from utilizing his sardine offal is sufficient to pay the running expenses of his cannery so that the return from the canning plant is "velvet." Although this case may be exceptional it indicates that the by-products of the industry have already assumed great importance and there is every indication that more and more fish waste will be utilized. There are at present several firms in California that make the utilization of waste fish their only business. A much larger number of reduction plants are operated in connection with fish canneries so that at present California stands well toward the top in the utilization of fish waste. The inedible or waste portion of the fish is now being converted into forms that indirectly serve as human food. Waste fish is reduced to fish meal which serves as food for animals and plants that are used as food by man. In other words we are now eating, directly or indirectly, nearer 100 per cent of the sardine than the former 50 per cent. The discrepancy in this 100 per cent consumption as human food lies in the fact that fish oil, a by-product of fish meal, is used for commercial purposes other than food. The edible oil refined from fish oil has as yet proven unsatisfactory although there is constant experimenting at present and a palatable salad oil may result.

Uses of fish meal and oil.

Fish waste was first dried and ground into fish meal to be used as a fertilizer for plants and its value as fertilizer has long been recognized. There was in the past a prejudice against using the meal for stock food because the oil in the meal was said to impart a fishy flavor to the flesh of the animal eating the meal. This has been overcome by extracting the oil from the meal before feeding it to stock. In fact the oil has been found to be so valuable that the cost of extracting it is unimportant compared with its sale value. Fish meal, by experiment and tests on a large commercial scale, has been found to be

*California State Fisheries Laboratory, No. 32.

exceedingly valuable as a stock food, equaling and exceeding tankage and grains as an animal food. Fish meal is now in demand as a food for swine and cattle but the largest demand is as a chicken food. Chicken raisers claim that fish meal has been found to be far superior to any other meaty food, as meat scraps or blood. Its value lies in its high percentage of protein, or more properly speaking, in its high nitrogen content in the form of ammonia and in phosphoric acid as bone phosphate. These are also the elements so much valued in fertilizers and fish meal now competes with the high grade nitrogen materials (as ammonium sulphate) and the cheap bone phosphates in commercial fertilizers. The chief demand in this state for the meal as a fertilizer comes from the fruit growers, especially the orange growers. The meal therefore has two chief uses, as stock food and as fertilizer. So far, the high price of the meal has largely confined its use to the more intensive growing of oranges and chickens and most of the sales are made to orchardists of southern California and to the Petaluma chicken raisers. Meal sold in the open market brings about the same price when sold either for fertilizer or for chicken food.

Sardine oil (as well as other fish oils) is used extensively in the leather tanning industry but the chief use of the clear oil is in the making of paint and the heavier fatty materials are used in the manufacture of soap.

Reduction process in general.

Fish contain a high percentage of oily fat, varying from 5 to 20 per cent in fresh sardines. This oil is not only valuable for other uses but it is a detriment in a stock food or fertilizer. The oil and fat are therefore extracted before the fish material is marketed as a fish meal. There are two general methods of removing oils from either vegetable or animal material. When the oil is to be used for human food it is usually pressed out. Oil to be used for commercial purposes other than as human food, is frequently removed by the use of a volatile solvent which takes up the oil. The solvent may then be volatilized and the oil recovered. The first fish reduction plants used the pressing method and this principle is still the one commonly used in the fish reduction plants of California. At present there are in the state but two plants using the volatile solvent method of extracting fish oil. This method will be described later. The usual practice (press method) is to cook the fish material sufficiently to loosen the flesh from the bones and break up the fish skeleton. The oil is then pressed out and later refined. The meal is then dried, cooled, and run through a grinder to break up bony particles. The meal is then sacked ready for shipment. There are minor variations in the application of the press method but the chief differences between plants are in the method of drying the meal rather than in the manner of pressing out the oil. One of the variations in method of drying will be described later. In order to give a more consecutive idea of the different steps in the reduction of fish to meal, it will be helpful to consider a description of a typical plant using the common press method for sardine offal.

A typical plant of the press type.

The plant selected for description as a typical fish reduction plant, is one operated in conjunction with a Monterey sardine cannery. The reduction plant normally receives 30 tons of sardine offal per day, although it is capable of handling much larger amounts if operated continuously through the day. The fish material is almost entirely sardine offal from the cutting tables of the cannery with the broken and under sized whole fish that naturally result from canning operations. The offal from the cannery is collected in a large storage bin from which a belt and bucket conveyor transports it to the top floor of the reduction plant building. The offal is about 45 minutes in passing through the plant from this storage bin to the drying floor as finished meal, but only a small amount may be run through at a time. Therefore the belt conveyor from the bin has small buckets that feed in only the proper amount of offal.

Cooker.

The older plants of Europe used to cook the fish in vats over a wood or coal fire but steam cooking is the common method now used in California. The cooking is done in a steam chamber or stationary horizontal cylinder roughly two and a half feet in diameter by 18 feet long and insulated with asbestos packing to conserve the heat. Offal is carried through this steam chamber at a uniform speed by means of a revolving auger action conveyor shaft whose revolutions are so timed that the fish remains in the chamber about 15 minutes. This revolving conveyor carries the cooked fish to the press.

Press.

The common form of press used in this state is a horizontal continuous screw press said to be a modification of the French olive press. The press is an auger shaped screw working into a metal jacket which is perforated with openings about the size of a pin hole to allow the water and oil to escape. The screw press is about seven feet long. The first three feet of the press casing or jacket is of lighter construction, with relatively larger holes for the purpose of draining off the free water. In the last four feet, or press proper, there is another screw revolving more slowly, and the distance between the auger flanges is reduced so that the material moves forward more slowly. This slowly revolving screw works against a deeply beveled stationary disk which blocks the forward progress of the material and allows it to escape very slowly in the form of a coarse paste scraped from the beveled edges of the disk. The escaping oil and water are caught in a drip pan and piped to tanks.

Dryer.

The pressed material, now in the form of a paste-like mass, must be dried to prevent moulding and souring. Drying is done by hot air. In this particular plant the drying is done by passing the fish through two horizontal stationary drums or cylindrical chambers each 30 feet long. A circulation of hot air from the furnace is forced through these drums or "dryers" by means of a rotary blower. A vent up the smokestack, provided with rotary section fan, carries off the moist air.

The fish paste drops from the end of the press into an auger conveyor and is carried through the first dryer. It then drops to the second reversed conveyor and passes back through the second drum, which is situated directly under the first. The material is now in the form of a somewhat moist, steaming hot meal. From the end of the dryer the meal enters a piped cold air blast which serves primarily in cooling the meal, but also transports it to the grinder. The press and the dryer break up the fish very thoroughly so that very little grinding is necessary except for occasional bones. The meal passes through a small motor driven grinder and drops on the floor where it is spread out for two or three days to complete the cooling process and to dry out more completely. It is usually shoveled over two or three times on the floor before being sacked in 90-pound sacks for shipment.

Oil recovery.

The oil and water which drain from the press are separated by gravity. The drippings from the press are run through a series of five settling tanks. In the first tank the water and refuse particles are allowed to settle to the bottom and are drained off into the ocean. The oil is syphoned over into the next tank in the series where the gravity separation of the fat from the oil is begun. The top or first oil in the last settling tank is a fairly clear oil but the complete clarifying of the oil by settling out the fat may require several weeks and is unnecessary. The clear oil from the top of the last tank has been used successfully as a paint oil without further refining or the use of a drier in the paint, but this is not the usual practice. The oil is shipped in barrels to paint factories where it is processed for use in paints. This fish oil sells for about one-third the price of linseed oil.

Below the clear oil in the tanks is found the cloudy fatty oils and thick fat material called stearine. The heavier stearine is called "foots." The stearine is sold for use in the manufacture of soap. As stearine contains from 40 per cent to 50 per cent oil it is sometimes heated and more oil drawn off but it usually goes direct to the soap manufacturer.

A modification of the press type.

In the typical plant already described, the fish material, after cooking and pressing, was dried by being carried through stationary drums through which was forced a circulation of hot air from the furnace, by means of rotary blowers. We will consider briefly a plant in which a very different form of dryer is used. In this case the dryer is a revolving drum without a conveyor through the center. A cylindrical drum (five and a half feet in diameter and forty feet long) is placed on a slight decline from the press (pitch of one-half inch to the foot). The hot air is provided by a blast of burning mixture of oil and steam in a firebox so arranged that the flame blast strikes a lattice work of brick allowing only the heated air to enter the drum. A direct flame is not introduced into the drum for fear of scorching the fish. At the opposite end of the drum the necessary air suction is provided by a tall smokestack (four feet in diameter and 60 feet high). On the sides of the drum are a few longitudinal cleats or "channel irons" which serve to tumble the fish material as the drum is rotated. The strong

draught of air and the pitch of the drum from the horizontal, serve to carry the fish waste forward as it dries out. The heavier particles of the dried material tumble out of the back end of the dryer and are caught and conveyed away by a large cold air suction pipe. There are about 200 feet of this air pipe with two rotary blowers so that the material is not only cooled, but is further broken up into fine meal. To prevent the lighter particles from passing up the smokestack, there is a series of three catching, or dust chambers, the operation of which will be described later when considering the volatile solvent method. The meal from the cooling pipes is spread on the floor for several hours for further cooling and is then sacked without grinding. The pressing and tumbling in the dryer and conveyor pipes reduce the material to a fine meal containing only a few bones that have not been completely broken up. In this form the meal is ready for use as fertilizer but it should be ground before used as a chicken food.

Anchovies difficult to press.

It frequently happens that a sardine catch contains a large percentage of anchovies, especially when small sardines are being taken. This is an important consideration because the ordinary screw press will not operate properly with a high percentage of anchovies, especially when the anchovies have been more than eight or ten hours out of water. The soft anchovies churn up in the press as a jelly-like mass that will not feed out and clogs the oil holes and the screw of the press. Anchovies may be used when mixed with sardine offal to lend more body to the material and thus pass it through the press. It is claimed that a mixture of half anchovies and half sardine offal will press fairly well but a lower percentage of anchovies is preferable.

Yield in meal by press method.

The solid flesh of the whole fish yields more meal than a like weight of offal, so that the percentage of whole fish in the offal effects the amount of meal recovered. The degree of fatness of the fish also affects the yield of meal since there is relatively more oil in a ton of offal from fat fish, but there is far less variation in the amount of meal than in the amount of oil recovered. In the typical plant already described the number of tons of sardine offal necessary to make one ton of fish meal varies from five and a half to seven and a half, with six tons as the probable average. The weight of the recovered meal is roughly estimated at one-sixth that of the offal in this plant. Other plants with somewhat different methods estimate the meal at one-fifth to one-fourth the weight of the offal. The remaining five-sixths of the weight is partially recovered as oil and stearine but most of it is water of which the greater per cent is driven off by evaporation. The water content of fresh sardines is high (probably 60 to 75 per cent) and canned sardines are about 60 per cent water but a low moisture content is desirable in both fish meal and oil. The meal contains less than 10 per cent moisture and the oil less than 2 per cent water.

Composition of meal by press method.

Fish meal sells on its chemical composition and frequent samples are subjected to chemical analysis. The chief value of fish meal lies

in its nitrogen and phosphoric acid content. The nitrogen as ammonia is the most important element and the price of a fish meal on the open market is largely determined by the percentage of ammonia present. The ammonia content varies between 8 and 14 per cent, but a high grade meal usually has between 10 and 12 per cent ammonia. The phosphoric acid content as bone phosphate is the next most important consideration in fixing the price. A low moisture content is desirable as the buyer does not care to pay for useless weight in water. The water content is not run below 6 or 8 per cent, not only because of the cost of further reducing the per cent, but also because the sacked meal will absorb sufficient moisture from the atmosphere to bring it up to 6 or 8 per cent. The moisture content of meal varies from 8 to 13 per cent but is usually about 10 per cent. The pressing method does not extract all of the fish oil from the offal and the resulting meal from this process contains from 7 to 10 per cent of oil (ether extract). The chemist's analysis of the meal produced by the typical plant we have considered gives the following results expressed roughly:

Nitrogen	9 to 10 per cent
Phosphoric acid	5 to 10 per cent
Nitrogen as ammonia	10 to 14 per cent
Phosphoric acid as bone phosphate	10 to 22 per cent
Moisture	9 to 12 per cent
Oil (ether extract)	8 to 10 per cent

The term protein is often used in the analyses of meal to include the proteids or nitrogenous matter of the soft tissues of the fish body. Such classifications divide fish meal into protein, oil or fat (ether extract), water and mineral ash. In such cases the protein content ranges from 50 to 60 per cent, a much greater percentage than in fresh fish with its higher moisture content. A rough rule of thumb sometimes followed when the nitrogen content of the meal is given, is to multiply the percent of nitrogen by 5.25 to give the protein content. In judging a fish meal it is essential to know the percentage of (1) ammonia, (2) phosphoric acid, (3) moisture, and (4) oil (given in the order of their importance).

Yield of oil by press method.

In sardines there is a great deal of oil in the flesh just back of the head but the fat about the entrails and the liver itself is especially rich in oil. In cutting sardines for canning, the fish is cut in two near the back of the body cavity and only the posterior half of the fish is canned. Thus the head and entrails are discarded as offal. Therefore a ton of offal will yield more oil than a ton of whole fish and the per cent of whole fish in the material will affect the yield of oil. The greatest source of variation is the periodic fluctuations in the fat content of the sardines themselves. At some seasons of the year they are very fat with a high oil content, while at other seasons, especially in the spring, the fish are thin and have relatively little fat and oil in their bodies. The fat content of sardines varies roughly from 5 to 20 per cent. As anchovies have much less oil than sardines a quantity of anchovies mixed in the offal reduces the oil

yield per ton of material. For the above mentioned reasons the yield of oil varies greatly from day to day and from month to month. In the typical plant we are considering, the oil yield varies from 7 to 27 gallons per ton of offal, with a rough average yield of 10 to 12 gallons of oil and fatty material (stearine) per ton of offal.

Composition of oil by press method.

Fish oil, like fish meal, sells on its chemical analysis. The oil with a small per cent of free fatty acids or unusable material is the high-grade oil bringing the best price. The impurities are referred to in the trade as free fatty acids and M. I. U. The M. is moisture and other volatile matter, the I. is insoluble impurities and the U. is unusable or unsaponifiable matter. The amount of impurities in an oil varies naturally with the method and care used in the refining or settling process. As more care is now being given to this phase of the subject, some of the west coast oils are finding ready sale locally and in the Eastern States. In the past the lack of care in refining and looseness in grading the oil has caused much of the west coast oil to be classed as inferior grade and accepted at a poor price by eastern buyers. For years the Newfoundland and American cod oils were the favorites till salmon oil was found to be equally good. The whale oil business, having been so long established, now has definitely established grades. The sardine oil, being new from this coast, has not yet come fully into its own. The use to which the oil is to be put largely determines the purity of oil necessary. A leading dealer in fish oils makes the general statement that fish oil for use in paints should not have over 5 per cent free fatty acids and not over 2 per cent M. I. U. For tanning purposes the oil should be from 5 to 7 per cent acids and 1 per cent M. I. U., but clear settled (tanked) oil for use in the better grades of soap should not exceed 3 per cent acids and 2 per cent M. I. U. For a No. 1 grade of sardine oil the limit of impurities is usually set at 2 per cent free fatty acids and 2 per cent M. I. U. The press method, with proper care in operating the settling tanks, yields a sardine oil low in acid content and well within the limit as to other impurities. The chemical analyses of the sardine oil produced by such a plant show the following results:

Free fatty acids	.5 to 1.5 per cent
Moisture and volatile matter	.1 to .7 per cent
Insoluble impurities	a trace to .03 per cent
Unsaponifiable matter	.2 to .9 per cent

Volatile solvent method.

In this method there is no press, the oil being recovered by the use of gasoline as a volatile solvent. The elimination of the press permits of the reduction to meal of almost any kind of fish material without readjustment of machinery or extra labor. Fish scraps, trimmings from the fish and abalone markets, offal, meat scraps, whole fish, sharks, squid and anchovies are reduced with equal facility. In the two California plants there is no separate cooking cylinder, but the cooking and drying are combined in one machine. In the press method the oil and water are pressed out and the material then dried. In the gasoline process the material is dried to eliminate the water and later the oil is

extracted from the dried meal. The two gasoline plants of this state are not connected with a fish cannery, but are operated as an independent business, purchasing the raw material from other firms. One plant uses mostly fish scraps and the other, located in one of the sardine canning centers, operates on sardine offal purchased from the canneries. A brief description of the latter plant will better illustrate the method. This plant has a capacity of about 35 tons of offal per day when employing five or six men. With seven or eight workmen the capacity can be increased to 50 or 60 tons per day. The sardine offal is transported to the plant by auto truck and dumped into a storage bin from which a belt conveyor with small buckets carries the material to the dryer. The conveyor is filled by hand so that the amount fed in may be varied according to the directions given by the man operating the dryer.

Dryer.

The dryer (cooker and dryer combined) is a large revolving horizontal cylinder, 40 feet long and 4 feet in diameter, operating on the same general principle as the dryer described above, under "Modification of the Press Type of Plant" which merely dried the cooked and pressed material. This dryer first cooks and then dries the fresh offal from the storage bin. The heat is provided by a burning spray blast of mixed steam and oil, the draught being created by a tall stack. In this case the flame is shot directly into the dryer. The conveyor empties the offal directly into this flame and the four or five longitudinal cleats of the revolving dryer keep it tumbling. The amount of flame and heat may be delicately regulated by adjusting the amount of oil and steam sprayed in. When fairly dry material is being received, the flames extend only two or three feet into the cylinder, but with particularly wet material the flames may be shot into the dryer a distance of eight or ten feet. The wet offal is tumbled in the flame during several revolutions of the cylinder till the material is sufficiently heated to cook the flesh free from the bones. As the moisture is absorbed by the hot air blast and the flames, the dried fish material, being lighter in weight, is blown toward the back end of the dryer. The cylinder is set up with only a very slight pitch downward, the draught being sufficient to carry the fish through. The fish remains in the dryer about thirty minutes from the time of entering the flames till it is blown to the back end of the cylinder as dry meal. The offal is not only cooked and dried in the cylinder, but the tumbling of the dried material breaks it up into a coarse meal, the chunks of which are usually no larger than a pea. In this drying process it is essential that the supply of material being fed into the dryer be uniform, in order to reduce as much as possible the readjusting of the flame. When a great amount of wet fish is fed in rapidly, the drying is not complete and the product is too moist. If the supply of raw material is reduced suddenly, or is much dryer than the preceding supply, the excessive heat burns the fish into hard cakes and extracts free oil, which collects in the bottom of the cylinder and sometimes catches on fire.

Recovery of meal from dryer.

As the back end of the cylinder is open, the meal is blown out into a small catching passage way which has a small hole in the floor to

allow the heavier particles of the meal to escape, but much of the meal is in the form of dust and is carried past this opening by the air current. In order to recover this dust, the air current is led through three dust chambers before it escapes up the stack. The opening into the first chamber is near the top and the outlet near the floor, so that the heavier dust settles to the floor. In the second dust chamber the intake is near the floor and the outlet near the top, so that the finer dust settles in this second chamber. The air current then drops again in a third chamber before escaping up the stack, so that all but a negligible amount of very fine dust is recovered. The dust chambers are emptied once or twice a day by opening a door in the side wall and shoveling up the accumulated fine meal. The dried meal is known as "unfinished stuff," as it has yet to be processed to remove the oil. This unfinished stuff is spread on the concrete floor to cool before it is elevated to the second story of the building in readiness for the next step in the process, the extraction of the oil.

Extraction tank.

The extraction tank is a heavy cylindrical steel tank about nine feet in diameter and about fourteen feet high. The tank is filled through a door in the top to within eighteen inches of the top with the dry unfinished meal. Gasoline is then sprayed in from the top through a perforated pipe till the tank is filled with gasoline sufficient to cover the meal. The tank full of meal and gasoline is then heated by introducing steam at the top of the tank. The heat is said to be about 325 degrees and is continuous for an average of about eight hours. The gasoline begins to take up the oil of the fish meal even before the meal is thoroughly heated, so that the process of draining off the mixed gasoline and oil is begun soon after the steam is introduced. The bottom of the tank is a sheet of steel perforated to allow liquid to drain through it. Under this metal sheet there are alternating layers of charcoal and gunny sacking to catch and hold particles of meal, so that the liquid may be drained off as pure as possible. After this oily gasoline is drained out, the tank is again flushed with a fresh supply of gasoline, which is also drained off. A small door in the side of the tank, even with the metal floor, is then opened and the meal pulled out.

Screening.

The meal that has been removed from the extraction tank is then screened or sifted to remove any of the larger particles that have not been broken up by the process so far. The sifted meal is then ready for sacking. The screenings or tailings consist of pieces of backbone, bones of the skull, especially the cheek plates or opercles, small hard lumps formed by a portion of the intestine, and a few chunks of meal that remain packed or were burned somewhat in the dryer. These tailings may be ground up and resifted, or, as is frequently done, may be run through the dryer again, which breaks up most of the chunks and saves grinding so much material. The tailings, after being ground up into fine particles, are mixed with the sifted meal and sacked. It is essential that the meal be quite dry before sacking. If there is much moisture, the meal will mould and heat in the sack. In case the final meal is found to be too moist, it is run through the dryer again before

sacking. The sacked meal should not have much over 10 per cent moisture.

Recovery of oil.

The liquid drained from the extraction tank is carried by pipe into a smaller tank called the evaporating tank, which is about 12 feet long and 5 feet in diameter. It is provided with a large steam coil capable of heating the liquid to 300 or 325 degrees. The heat volatilizes the gasoline and a pipe at the top of the tank carries off the gas thus formed. After about four hours practically all the gasoline is driven off, leaving only the fish oil remaining in the tank. If much gasoline is left in the oil and the oil is later refined, a serious explosion is apt to result, so that it is essential to drive off all the gasoline possible. The oil is then blown out of the tank by steam pressure and conducted by pipe to a storage tank. The oil is later deodorized by heating to about 600 degrees, which also removes practically all of the moisture and other volatile impurities. The oil is then ready for shipment to the paint manufacturer.

Recovery of gasoline.

The volatilized gasoline escapes from the evaporating tank in a pipe that is run through a condenser or coiled pipe in a bath of running cold water. Ocean water is particularly good for cooling the condenser pipe. The condensed gasoline drains into a storage tank and is ready for use again in the extraction tank. This distilled gasoline is referred to as "high power gas" because of its greater strength in taking up fish oil in the extraction tank. The high power gas has been freed from many impurities and is much more volatile than ordinary commercial gasoline. In fact the commercial gasoline is usually run through the evaporating process to refine it before it is used in the extraction tank.

Composition of meal.

The meal resulting from the gasoline method has practically the same moisture, phosphoric acid, bone phosphate, nitrogen and ammonia content as in the press method. The meal has about 10 per cent each of nitrogen and moisture. The phosphoric acid content is 7 to 8 per cent and the bone phosphate is in the neighborhood of 16 per cent, although quite variable. The ammonia content is 8 to 12 per cent. The chief difference in the two meals is in the oil content. The volatile solvent method removes more of the oil than the press. The final meal by the gasoline method has about 3 per cent of oil as contrasted with 8 to 10 per cent of oil by the press method. Therefore the oil yield per ton of offal is higher by this method than by the press method, the yield being about 20 gallons per ton of offal. The yield of meal is said to be about 23 per cent of the weight of the offal. This yield is as good or better than the percentage of meal recovered from pressing. Practically all of the meal from this plant is sold for chicken food and is shipped to Petaluma.

Quality of oil by gasoline method.

By the gasoline extraction process the resulting oil, although relatively of greater quantity, is not the high quality oil obtained by methods of pressing. When the fish first enters the dryer and is tum-

bled in the flame blast, the oil in the fish is sufficiently scorched so that the resulting oil is black or dark brown, and up to the present time has not been refined to a clear oil. For this reason its use is almost entirely confined to the manufacture of paints, where its color is no drawback except that it is unfit for use in white paint. This dark oil seems to give good satisfaction in colored paints, other than white, even in cream colored paint. The recovered oil has very little of the heavy fatty materials as foots or stearine. So little saponifiable material is recovered that it does not, at present, pay to separate it for sale to the soap manufacturers.

The following are a few of the many bulletins published by the U. S. Department of Agriculture, and may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.:

Bull. 378. Fish Meal: Its use as a Stock and Poultry Food. (1916.) 5 cents.
Bull. 150. Utilization of Fish Waste on the Pacific Coast. (1915.) 15 cents.
Bull. 2. Fish Scrap Fertilizer Industry of the Atlantic Coast. (1913.) 10 cents.
Bull. 635. Commercial Freezing and Storing of Fish. (1918.)
Bull. 908. Maine Sardine Industry. (1921.) 50 cents.

Fig. 63. Hauling in a sardine net. The wings have been hauled in and the lead line raised, impounding the fish in the bunt of the net. Photograph by Messrs. Higgins and Holmes.

METHODS OF SARDINE FISHING IN SOUTHERN CALIFORNIA.*

By Elmer Higgins and Harlan B. Holmes.

It is a fixed purpose of the California Fish and Game Commission to maintain a system of fishery statistics so complete and so continuous that the varied and changing conditions of the fishing industry may be compared year by year in order to determine its actual condition and future prospects. As a partial supplement to the statistical records of the catch, collected and compiled according to law, these notes on methods and practices are prepared to aid the investigator in future years to reconstruct in his mind the actual conditions in 1921, enabling him to understand and interpret the figures of the catch.

LOCAL CONDITIONS AND GEAR.

Local conditions have their natural effects upon methods and gear, producing in southern California an industry unique in many ways. The sardine fishery is not an independent industry, for the fisherman engaging in it spends fully half of the year fishing for albacore, tuna, sea bass, mackerel, halibut, or rock cod, and hence his boat and gear are modified to meet the requirements of these other fisheries. By far the greater number of boats fishing sardines are typical albacore boats which are converted for use during the winter sardine season by the removal of bait-boxes and poles. Many, however, of a different type, were built before the albacore fishery became so profitable, and are used, during the off season for sardines, in fishing with trammel nets for halibut, or with set lines for rock cod. These two distinct types of boats are manned, respectively, by the two nationalities which dominate the fishery, the Japanese and the Italians.

Weather conditions also have influenced the type of boats used. Although the boats are perfectly seaworthy and capable of traveling several hundred miles, the uniform character of winds and absence of sudden storms has permitted the development of a type of fishing boat poorly adapted to a short choppy sea, being long and narrow and having a wedge-shaped bow with little flare.

THE LOCATION OF THE FISHERY.

The California sardine, *Sardina caerulea* (Girard), occurs in considerable abundance along the entire west coast of the United States, including Alaska and British Columbia, and southward on the coast of Lower California, but the chief centers of the fishery are Monterey, San Pedro, and San Diego. In southern California sardine canneries are located at San Pedro, Wilmington, Long Beach, Newport Beach, and San Diego, the areas fished covering a radius of fifty miles or so from these points. In the San Pedro district, deep water fishing off a rocky coast is found from Point Firmin north to Redondo and off sandy beaches from Point Firmin south to Newport. At San Diego similar conditions are found to the north, about La Jolla, or from Point Loma south to the Mexican border. The winter sardine fishery is chiefly in

*California State Fisheries Laboratory, Contribution No. 33.

deep water two to ten miles from shore, but in the summer, fish are caught inshore near the sandy beaches.

FISHING SEASON.

The sardine canning industry, which utilizes practically the entire catch in the San Pedro district, depends a great deal upon the large fish 20 to 30 centimeters long, known as "pound-oval" size, from the cans in which they are packed. The fish approach the coast in December and are taken in great quantities until April or May, when smaller sizes become relatively more numerous, but canning sometimes starts early in November, utilizing the smaller sizes of sardines known to the trade as "quarter-oils." (Fig. 64.) The same sizes are taken at San Diego, but a larger proportion of the pack consists of the smaller fish, and the season is therefore somewhat extended.

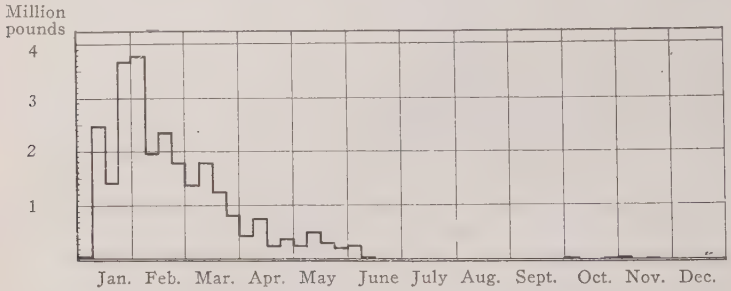


FIG. 64. The 1920 sardine season at San Pedro as shown by the Commission's reports of amounts of sardines received weekly at the canneries.

A summer sardine fishery, scarcely less important economically than the winter fishery, although yielding no statistical record and having no money value, is pursued from Santa Barbara to San Diego. It is the bait fishery, an essential factor in the summer albacore industry. Small sardines of "quarter-oil" size or smaller are highly prized by the albacore fishermen as live bait, and one-half to three-quarters of a ton per boat are taken in the morning whenever possible off sandy beaches before proceeding to the albacore fishing grounds. It is true that anchovies serve as a substitute, but they are not as desirable nor as much sought after as are the small sardines. This bait fishery continues throughout the albacore season, *i. e.*, from June to October. Modified sardine nets called "bait nets" are used and will be described later.

TYPES OF GEAR.

Boats.

As mentioned above, there are two chief types of boats employed in the sardine fishery: one operated by the Italians and the other by the Japanese. Americans (native born), Scandinavians, and Austrians also

engage in sardine fishing, but only in small numbers,* and they use boats which may be classed with one or the other chief types.

The Italians were probably the first sardine fishermen on the coast to use the present style of round-haul nets, and introduced their methods and gear from Italy. Their boats reflect an adaptation to trammel-net or set-line fishing after the sardine season, being smaller than the Japanese boats and having less power and speed.

A typical Italian sardine boat (Figures 65 and 66), carrying a crew of five or six men, is 35 feet long, of 10-foot beam, and 4-foot draft, with a wedge bow and fantail stern. A 20-foot mast is stepped in near the

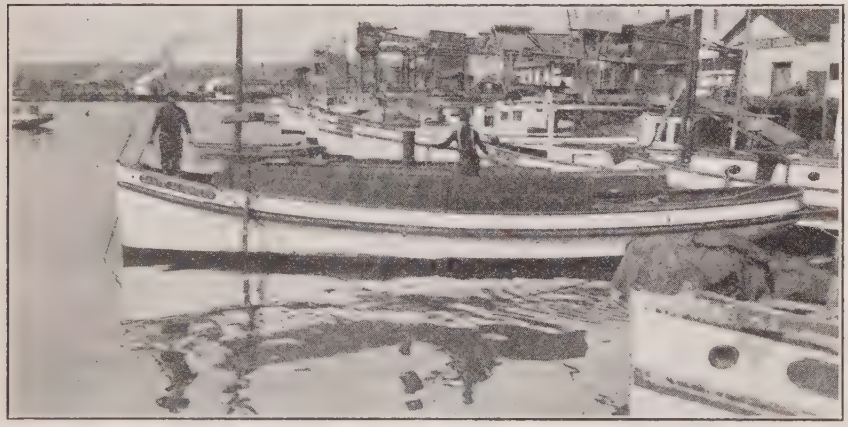


FIG. 65. A typical Italian sardine boat. These boats are also used for fishing halibut with trammel nets and barracuda with gill nets.

bow, and a low trunk cabin runs aft from this half the length of the deck. The space below is occupied by a two- or three-cylinder distillate engine of 20 to 30 horsepower and sleeping quarters for four. In the afterdeck is a hatch opening into a hold where nets or gear are stored

*The following table gives the nationality of fishermen in southern California, as compiled by the Commercial Fisheries offices of the Commission at San Pedro and San Diego from fishing licenses issued for 1920-21:

Nativity	Aliens	Citizens	First papers	Total	Per cent of total fishermen
Japan	1,025			1,025	42
Austria	357	31	104	492	20
United States		328		328	13
Italy	257	9	15	281	12
Dalmatia	66	5	13	84	3
Scandinavia	51	17	13	81	3
Balkan States	22	4	8	34	1
Russia	16	4	1	21	1
All others (10)	78	15	5	101	4
Total	1,872	423	159	2,447	99
Per cent of total	76	17	6	99	

Austrian fishermen engage almost entirely in purse-seining for tuna, barracuda, and sea bass, while native Americans and many Japanese fish chiefly in the summer for albacore. This leaves the Japanese and Italians dominant in the sardine fishery.

and where rock cod or halibut may be iced or stored fresh, when set-line or trammel-net fishing. The operator stands in the open cabin hatchway amidship, his hands on a small steering wheel inside the cabin and his feet operating the controls of the engine. On some boats a movable box-like hood with glass windows in its sides is placed over the open hatch to protect the head and shoulders of the operator from the weather. The speed of such boats is from six to eight miles per hour and they are relatively economical in operation. Their small size, however, reduces the capacity and their speed limits the radius of operation in the sardine fishery. It also unfits them for the more strenuous duty of catching albacore.

The Japanese type of sardine boat is a modification of the earlier market fishing boat and is built primarily for the catching of albacore. It is longer, speedier, and more powerful than the Italian boats, and more comfort is provided for the operator by building an enclosed pilot house amidship. It is thus adapted to traveling greater distances in search of schools and returning with the catch in less time.

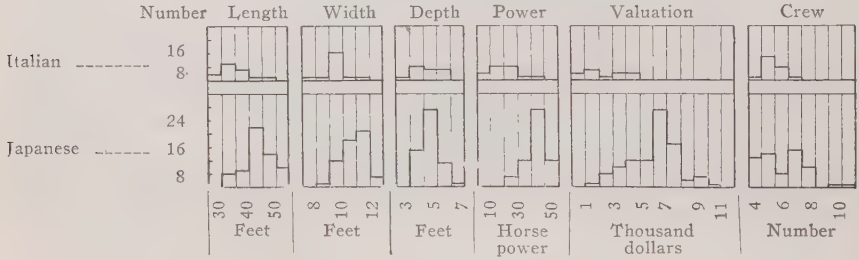


FIG. 66. A comparison of Italian and Japanese types of sardine boats at San Pedro, 1920–21. Data from boat registration records.

A typical Japanese sardine boat (Figures 66 and 73), carrying a crew of seven or eight men, is 45 to 50 feet long, of 12-foot beam, 5-foot draft, and powered with a three-cylinder distillate or crude-oil engine of 40 horsepower, which drives the boat at a speed of from 9 to 12 miles per hour. The vertical bow is wedge-shaped and the stern of fantail type, but broad and rather square. A low trunk cabin with a hatchway on the side runs from near the bow to the pilot house amidship, which is placed directly over the engine. The controls are arranged in the pilot house so that one man operates the boat. The forward cabin is small, having bunk space for two or three men, but extra bunks are fitted in the hold beneath the afterdeck and may be reached through a raised hatch just aft of the cowl or extended roof of the pilot house. A take-down mast set at the forward end of the cabin is carried in a horizontal position, one end resting on the pilot house. The catch of fish is piled all over the afterdeck and along the sides of the cabin as far forward as necessary, and is confined by side-boards which may be built up on the gunwales three or four feet high, according to the size of the load. A space about six feet wide and running athwartship is reserved in the stern of the boat for piling the net and for standing when paying it out or hauling it in again. The

fish are kept out of this area by a low transverse bulkhead or partition which may be built up in the same way as are the sideboards. In the center of this bulkhead is erected a standard bearing an electric light on a swinging arm to light the deck for night hauling.

This is the newer type of boat representing three-fourths of the fishing craft in southern California, and is now being built for fishermen of all nationalities, Japanese and Italians alike, for use in the albacore and sardine industry.

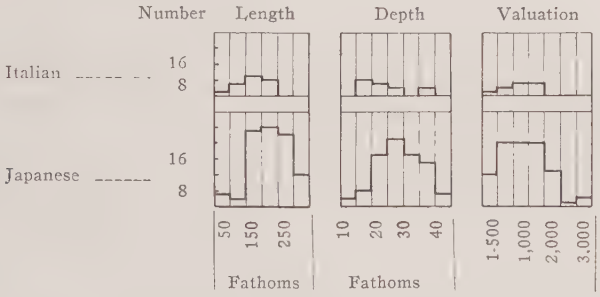


FIG. 67. A comparison of Italian and Japanese types of sardine nets at San Pedro, 1920–21. Data from boat registration records.

Nets.

Sardines are caught entirely in huge nets laid out in circles and hence called "round-haul" nets. Italian and Japanese nets are alike in principle and general plan, but differ in details of design as completely as do the types of boats (Figure 67). Any round-haul net is made in three sections: a right wing, a left wing, and a bunt or bag. The wings are long strips of large meshed net attached at each side of the bunt and are used to encircle the fish and drive them into the bag. The bag is the sacklike center portion of the net, made of fine meshed webbing and used to hold the fish until they may be landed on the boat. The webbing of wings and bunt is fastened to a light rope called the "cork line," buoyed with numerous corks so that the whole net floats in the water with the cork line on the surface. The lower edge of the net is fastened to a similar line—the "lead line"—weighted with leads at frequent intervals. These two ropes, in addition to floating and ballasting the net, take much of the strain of hauling and serve as reenforcement for the edges of the webbing.

Webbing manufactured in Japan is more popular in southern California for making sardine nets than the American or European product, partly, at least, on account of its lower cost. Hard-laid cotton seine twine is preferred for wings and landing sack, and cable-laid twine for the greater part of the bunt, particularly the fine mesh; but notions of economy lead some to use the cheaper and less durable medium-laid twine in the wings.

Each fisherman or boat owner builds his net after his own pattern and according to his latest ideas, producing a diversity of design which no doubt makes for progress in the developing of perfect gear. This great diversity makes it difficult to select a type, and when once

selected it is almost impossible to draw up specifications which could serve in building a net like the original, for net making is an art and can be learned only by experience. Two nets apparently of the same design will fish with different success, due to the individual skill of the makers expressed in the "hang" of the webbing; hence, the accompanying diagrams must not be considered as working drawings, but only as sketches sufficiently detailed, it is hoped, to portray the characteristic points of the types.

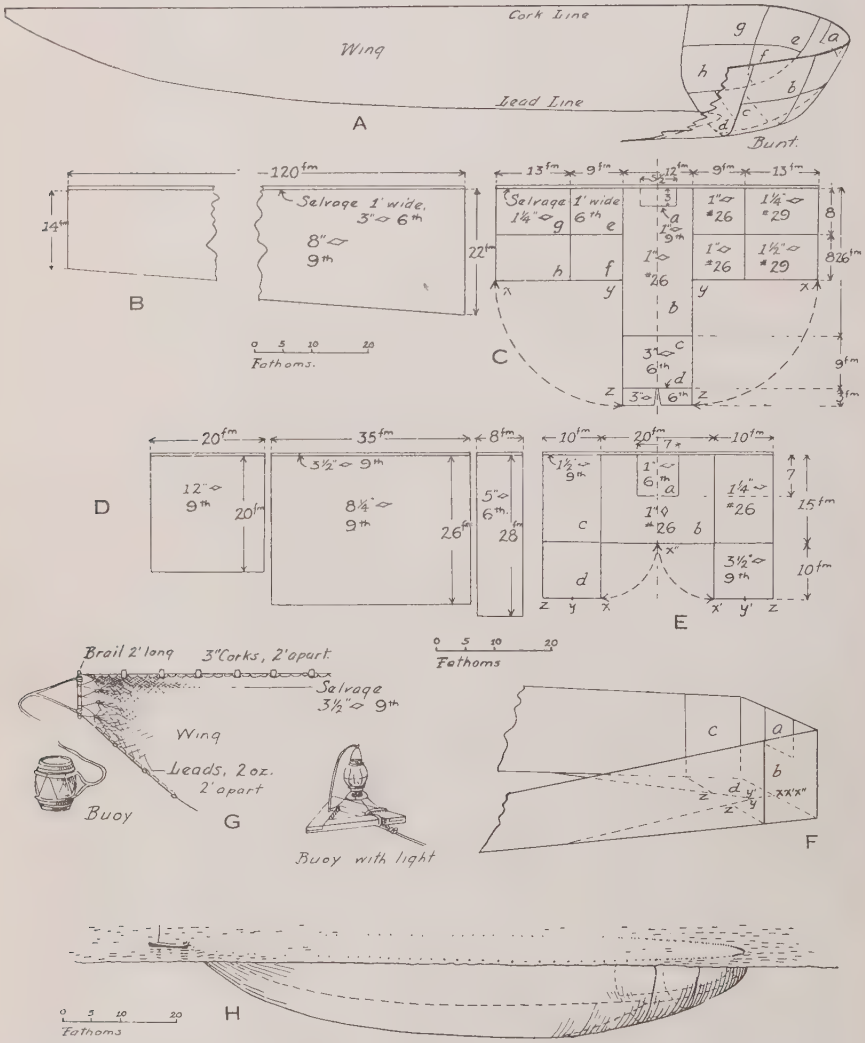


FIG. 68. Diagrams of Italian type of sardine round-haul net or Lampara. A, a perspective diagram of a large Lampara. The right wing only is shown. B, and C, wing and bunt respectively of same, showing pieces of webbing used. The pieces *a*—*h* are lettered the same in A and C to indicate their relation. The lines *x*-*y* and *y*-*z* in C are brought together to form a bag. D, the wing and E, the bunt of a smaller net. F, the bunt of the same net showing the relation of pieces in E. The points *x*, *x'* and *x''* are brought together and the lines *x*-*y* and *x'*-*y'* are joined as in F. In all diagrams, *a*, is the fine meshed landing sack of heavier twine than the rest of the bunt. G, end of wing and buoys for day and night fishing. H, a large net in operation showing relative length and depth compared with a forty-foot fishing boat.

The "Lampara" or Italian round-haul net.

A typical Italian sardine round-haul net or "Lampara" (Figures 67 and 68) is between 150 and 200 fathoms long, and between 15 and 20 fathoms deep, although some reach 300 fathoms in length and 28 fathoms in depth. The webbing is $\frac{3}{4}$- or 1-inch mesh of six-thread or sometimes nine-thread twine in the landing bag, and 1-inch to $1\frac{1}{4}$-inch mesh of No. 26 and No. 29, cable-laid twine in the sides of the bunt. The bed of the net is made of a piece of 1-inch No. 26 cable-laid mesh next to the landing bag and pieces of $2\frac{1}{2}$- and $3\frac{1}{2}$-inch mesh of six-thread hard-laid twine next to the lead line. A strip of heavier webbing about a foot wide, of $1\frac{1}{4}$-inch mesh and nine-thread twine runs the entire length of the bunt and serves as a selvage to which the cork line may be more firmly hung. A similar piece of selvage runs the length of the wings, but is usually $3\frac{1}{2}$-inch mesh of six-thread, hard or medium-laid twine.

The wings are commonly made of three sizes of mesh, the smallest being near the bunt and the largest at the ends. In a 200-fathom net the bunt is 40 fathoms long and each wing twice as long as the bunt, or 80 fathoms. Of this length, about 10 fathoms is 3-inch mesh, six-thread twine, 45 fathoms of 8-inch, six-thread, and 25 fathoms of 12-inch mesh, nine-thread twine. The piece of 3-inch mesh is fastened to the bunt of the net and is the same depth, *e. g.*, 28 fathoms. Each succeeding piece is reduced somewhat in depth so that the wing tapers to 15 or 18 fathoms at the end. This amount of webbing at the end of the wing is, however, gathered into bunches and fastened to a 2-fathom rope or to a wooden brail 2 feet long. Some prefer more pieces in the wings, beginning with smaller mesh, such as $2\frac{1}{2}$-inch, and running 3-inch, 5-inch, and 8-inch mesh at the end of the wings. Others use 8-inch mesh throughout the whole wing (Figure 69).

FIG. 69. Lampara net stretched on the dock for drying and mending. Fish Harbor, East San Pedro.

The cork line from which the whole upper edge of the net is hung is a $\frac{1}{4}$-inch manila line carrying 3-inch corks strung through their centers. Double corks four or six inches apart are placed the entire length of the bunt, and single corks, four, twelve, and eighteen inches apart are used on the wings. The corks are placed close together in the bunt and on the first sections of the wings to add greater buoyancy so that the weight of the fish in the sack, when making a haul, is less likely to pull the net under water and thus allow the fish to escape. The mesh of the bunt and wings is "hung full" on the cork line—*i. e.*, the cork line is shorter than the stretched webbing so as to allow for bagging of the net, by that means giving more room inside the bag and making it pull more evenly in the water. The amount of fullness left in the webbing depends upon the ideas of the individual maker. One method is to stretch the cork and lead lines by soaking them all night in water and then hanging the dry webbing upon them evenly the next day. The webbing will then stretch relatively more than the cork and lead lines when in use, relieving it of excessive strain and permitting sufficient bagging of the mesh. Another method is to first stretch the dry cork line, fastening in position temporarily at intervals the required amount of dry webbing, and later hanging permanently. In this way about 45 or 50 fathoms of webbing are hung on 40 fathoms of cork line to give sufficient fullness.

The lead line is also a $\frac{1}{4}$-inch manilla rope, like the cork line, but is strung with two-ounce leads one or two feet apart along its entire length. This amount of lead is just sufficient to make the bottom of the net fall readily and straighten out in the water.

The Japanese round-haul net.

The Japanese type of sardine net, although introduced into California later than the Lampara, has grown in popularity and now far exceeds the latter in numbers used. The Japanese net resembles the Lampara in a general way, but differs from it in size—both length and depth—in the shape of the bunt, and in the relative proportions of the bunt and wings.

A typical Japanese sardine net is from 200 to 250 fathoms long and from 25 to 30 fathoms deep, although many are 300 fathoms long and from 35 to 45 fathoms deep (Figures 67 and 70). The bunt is from 30 to 50 fathoms along the cork line, and the wings from three to three and one-half times this length. The mesh is commonly 1-inch, nine-thread in the landing bag; $\frac{3}{4}$-inch No. 26, cable-laid, in the sides of the bunt; 1-inch No. 26, cable-laid, lower down; and $3\frac{1}{2}$-inch, six-thread, hard-laid, in the bed. The wings are made up of three or five pieces of webbing of different size, of from 3- to 8-inch mesh, arranged as in the Lampara and tapering in depth. A strip of heavy mesh or selvage runs the entire length of the cork line, as in Italian net, but, in addition, a strip of two or three heavy 3-inch meshes runs down the sides of the bunt, making a firm selvage for the attachment of the wings.

A special feature used in some Japanese nets is the purse-line or quarter-rope, a $\frac{3}{4}$-inch rope, one end of which is fastened to the middle of the lead line by a short halter, and the other end to the lead line of one wing about 15 fathoms out. This line is used to raise the middle of the lead line of the bunt more rapidly than could be done by hauling

only on the wings. This is a desirable feature, for as soon as the lead line is raised the catch is made certain, the fish being then confined in the fine-meshed portion of the net.

It is difficult to discuss the relative merits of the two types of sardine nets, as both Italians and Japanese seem equally successful in catching

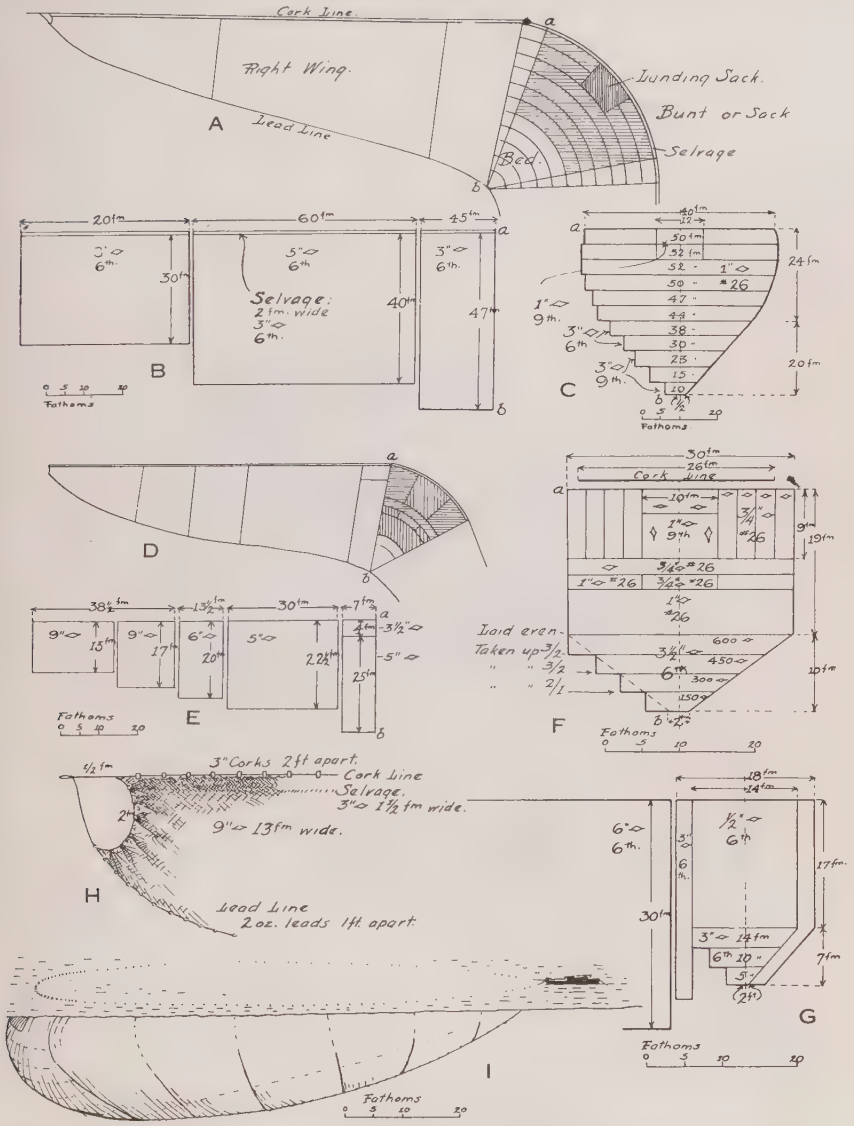


FIG. 70. Diagrams of Japanese type of sardine round-haul nets. A, a large net showing wing and bunt. B, and C, wing and bunt respectively of same, showing pieces used in making. The adjacent edges are brought together evenly by taking up the longer into the shorter lengths. The left side of C shows the pieces stretched and the right side after being taken up. D, a smaller net; E, and F, wing and bunt of same. Many more pieces than indicated may be used in the wings to produce the proper taper. G, the bunt and part of the wing of a bait net. H, method of fastening the end of the wing. I, a net in operation showing relative length and depth compared with a fifty-foot fishing boat.

fish. The popularity of the Japanese nets may be due to the great increase in the number of Japanese fishermen who naturally use their own methods, and the acceptance of this type by other nationalities may be due to its relatively simple design. It is argued that the greater depth of the Japanese type makes the net more generally useful than the Italian, since it can be used in deeper water away from shore. It is further said that the smaller amount of fine-meshed web in the Japanese net reduces the cost of construction and allows the building of a larger net with greater fishing capacity without corresponding increase in cost. Other fishermen declare that it is less difficult to operate a Japanese net, as cross currents are less likely to close the bag than is the case with the Lampara, and that the greater proportion of large mesh makes the net easier to pull. Whatever the facts may be, the fisherman of each nationality stoutly maintains his belief in the superiority of his gear, and both types will probably exist as long as Italians and Japanese continue to fish for sardines.

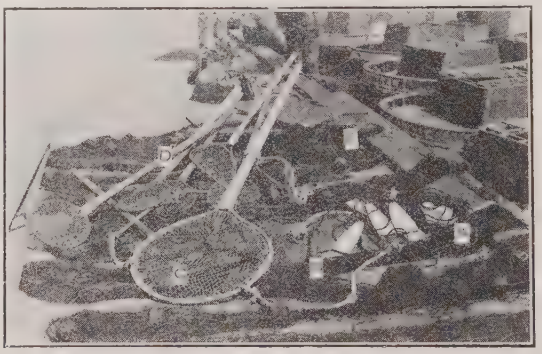


FIG. 71. Miscellaneous gear. A, and B, line and weight of the scare, with paddles piled between; C, dip-net for landing the fish; D, shovels used in unloading; E, side boards and checks for confining the catch on deck.

Bait nets.

The bait net is an important modification of the standard sardine gear. It is an almost necessary piece of equipment for the albacore boat, for live bait is required daily during the summer season. Some fishermen, moreover, make a practice of supplying small sardines to the market to be used as bait for the mackerel and set-line fisheries, and for this, bait nets are used. Bait nets are small sized Lamparas or Japanese style round-haul nets ranging from 75 to 150 fathoms in length and from 12 to 20 fathoms deep. They are usually more simple in construction, fewer pieces of webbing being used. The webbing in the bunt is of $\frac{1}{2}$- or $\frac{3}{4}$-inch mesh, but the mesh of the wings is about the same as in the larger nets.

Miscellaneous gear.

Many other kinds of gear may be mentioned which are used directly in catching or handling sardines, such as buoys, skiffs, plungers or scares, and dip-nets (Figure 71). A brief description of each will be given here, but details of their use will be left until later in this paper.

The Italian fisherman uses a red-painted, five-gallon keg as a buoy to float and mark the end of his net when fishing in the daytime. For night fishing, either a similar keg, weighted, and carrying a lantern, or a simple buoy made of crossed pieces of wood so as to float level and carry a light, is used. The Japanese, however, tow a twelve-foot skiff, lighted with a lantern at night, behind their fishing boat, to be used in place of the buoy.

The scares or plungers used in driving the fish back into the net are of many kinds. The simplest form is a weighted board two or three feet long, fastened to a ten- or fifteen-fathom line. Another kind used on some boats is a two- or three-foot length of iron pipe, open at the lower end but fitted to a short wooden pole at the other. This is also fastened to a light line so that it may be thrust down and rapidly hauled in again. Still another type is made by weighting one end of a long rope with a ten-pound window weight and fastening eight or ten white-painted wooden paddles about ten inches long and four inches wide at fathom intervals along its length. This seems to be a very efficient scare, as the paddles dash about irregularly when the line is jerked up and down in the water.

Two kinds of small ring nets are used: one is a dip-net for bailing the fish out of the water, the other really a shovel for unloading the catch. The dip-net is a shallow bag of heavy 2-inch webbing fastened to an iron ring two or three feet in diameter which is fixed on a heavy pole or handle about eight feet long. Short lengths of rope are fastened to either side of the ring to help in lifting the net filled with fish on board the boat. Another rope is fastened to the bottom of the net and is used in dumping the fish by raising the bag. The small nets used as shovels are made of heavy mesh stretched tightly over iron rings ten inches or a foot in diameter, with wooden handles four feet long. They may be circular, square, or semicircular, with the flat side away from the handle to make it easy to shovel up the fish from the flat deck. These particular implements are used instead of iron shovels to avoid cutting or bruising the fish more than necessary in unloading.

Care of gear.

Sardine nets are continually in need of mending. Defective meshes giving away causing small tears, large fish becoming entangled or plunging through the net, hidden snags—a hundred causes—keep the fisherman mending and mending before and after hauls and while waiting to unload the catch. Frequently the weight of the fish caught in the net is so great that rents are made great enough to allow the whole catch to escape. If possible, the repairing is done on the boat, but if the damage is too great the net must be spread out on the dock, and the whole crew goes to work with full-wound seine needles to repair the tear.

The standard method of preserving net material is by tanning the webbing in a hot decoction of red-oak tan-bark (Figure 72). Two sacks, or 120 pounds of bark, is placed with 100 gallons of water in a large tank and boiled for one hour. The fluid is allowed to cool somewhat and the net is put in and soaked for two hours or more, at a temperature less than boiling. Care is exercised to avoid heating too much, as the net is said to burn, causing quick "rotting" of the fabric.

Many canneries provide vats for tanning, heated with steam coils, but where the fisherman does not have access to such equipment he heats his tanks of tanning solution with a wood fire built in a pit in the ground. Nets are never tanned before storing away at the close of the season, but only while in actual use, for it is believed that rotting is more rapid when an excess of tan is left in the fabric.

Nets are dried as frequently as possible as a precaution against rotting, and windy days or periods when fish are scarce are always occupied with spreading nets on the docks or on the sandy ground for drying and mending. Rotting of the net when wet is also guarded

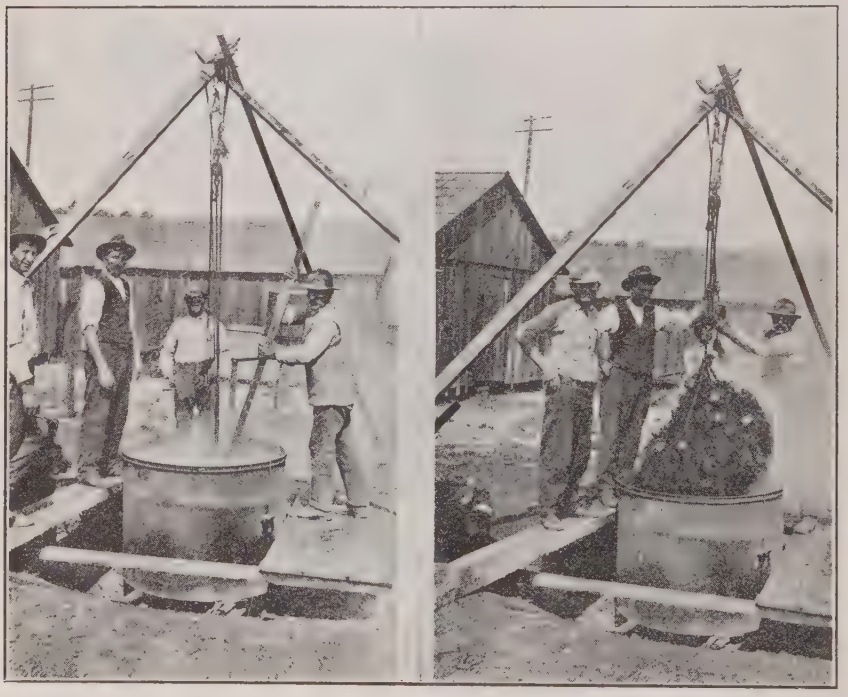


FIG. 72. Tanning nets. The nets are preserved from mildewing by soaking for several hours in a hot decoction of tan bark.

against by careful protection from the sun. As soon as the day's catch is made, the net is piled in order and covered with a tarpaulin made of heavy canvas.

Cost.

With ordinary care, a sardine net will last for two fishing seasons, but during the third season it is usually necessary to replace so many pieces of webbing that the net can hardly be called the same as the one at the start. A sardine net at the prevailing prices of the last two years, represents an outlay of from $1,000 to $3,000, but the cost of continual repairs makes the annual cost of operating a net from $300 to $1,000.

METHODS OF FISHING.

Time.

It is the fixed opinion of some that day fishing yields more mixed or small sizes of fish than night fishing; others notice no difference. Large and small fish are caught both day and night, but it may easily be true that differences in the schooling of the fish make the larger fish more accessible at night and so increase the average size of the fish in the total catch. At any rate, the demands of the canneries for large fish—pound oval size—combined with the greater accessibility is responsible for the greater part of the sardine catch being taken at night. The fish are most easily located on the darkest nights, hence, the two-week period during the dark phases of the moon is most successful. Day fishing is only resorted to when less than two or three hours of darkness is left between nightfall and moon-rise or moon-set and dawn. When fishing in the day time, the hours of early morning are the most favorable as the schools of fish can be most easily located when the water is calm.

FIG. 73. Searching for schools of fish. The crew on the bow and the man on the pilot house anxiously scan the sea for birds, darkened areas of water, or ripples on the surface which indicate the presence of fish. A typical Japanese boat.

Locating the school of fish.

The schools are located at night by the phosphorescent light produced by the movement of the fish in swimming. This explains the dependence of the fisherman upon the phases of the moon, as even a small amount of moonlight, or even bright starlight, makes it difficult at times to see the pale light of the phosphorescence. The running lights of the fishing boats are even darkened by covering them with cloth so that they may be seen at a short distance by other boats but will not give enough light to obscure the evidence of fish. Very dense schools may often be located at some distance by the dull "fire" but when the fish are more scattered it is necessary to pass over them to discover their presence.

Smelt and anchovies school closely enough and are near enough in size to be mistaken for sardines by the ordinary observer, at least at night, but the fisherman distinguishes between them readily by the courses of the fish as they dash away from the boat. Smelt swim away

in undulating courses leaving wavering, snaky trails of light. Anchovies, being feebler swimmers, dart away in short, curved dashes. Sardines are more powerful and dash away, leaving long slightly curved trails resembling the luminous paths of sky rockets.

There are several ways of locating sardines in the day time (Figure 73). A school may be discovered at a distance by seeing the gulls, fulmars, and shearwaters flying in circles and feeding upon the splashing fish. The water may also appear dark from the mass of fish below, and at close range the fish may be seen splashing on the surface. The character of the splash serves to distinguish sardines from anchovies, the former throw their tails above the surface without a marked silvery flash, while the latter flip over sidewise on the water showing their silvery sides and reflecting flashes of light. Some fishermen locate deep-lying schools in quiet water by the "bead"—minute bubbles which come up from below and bead the surface of the water like rain drops.

Making a haul.

Having located a school of fish dense enough to warrant an attempt, the crew stands in readiness to lay out the net while the skipper, noting the wind and current, circles and maneuvers the boat into proper

FIG. 74. Hauling in the wings. The activity here shown is accompanied by the excitement one feels before actually landing any other kind of fish.

position. The net is always laid out in relation to the direction of the wind so that the boat may not blow back over the net, and to the direction of the current, so that the net may not be swept shut or prevented from opening fully.

In making a haul, the net is laid out in a huge circle about the school of fish, the ends brought together and hauled in, impounding the fish in the bunt of the net. Running ahead at full speed, the skiff is released or the buoy thrown overboard, and its weight drags the end of the net into the water. The net is piled in the stern of the fishing boat so that one wing is paid out first, cork line and lead falling far apart in the water so as not to tangle. When one wing is paid out, the whole pile of bunt is thrown overboard at once, and the second wing is then dragged out by the weight of the net and speed of the boat. When the net is nearly all overboard the boat slows down in preparation for picking up the skiff, but should all of the net be paid

out before the skiff or buoy is reached, a one-inch line already attached to the net is slacked away under strain as far as necessary, and then hauled in again when the other wing is reached.

As soon as both ends of the net are recovered, the launch is anchored at once, if in shallow water, with a light kedge anchor, the skiff tied

Fig. 75. Sardine fishing in the black obscurity of midnight. This is the typical condition under which ninety per cent of our sardines are caught. Above, hauling in the bag; below, dipping the fish from the net.

forward out of the way, and all hands immediately begin hauling in the net with all possible speed (Figure 74). Care is taken to pull both wings at the same rate, cork line, lead line, and webbing coming in evenly; and as an aid, marked corks are placed on each wing at equal distances from the center. While the wings are being hauled in, one man operates the scare or plunger described above. This scare is

jerked vigorously up and down at the stern of the boat to frighten the fish back into the net and prevent their escape from the open side beneath the boat.

The wings of the net are hauled in until the lead line, being shorter than the cork line, is brought on deck. Thus far all work has been performed in absolute darkness, every light on the boat being entirely darkened so as not to attract the fish toward the boat and out of the net, but as soon as the lead line is brought on deck making escape impossible, the deck lights and running lights are turned on (Figure 75). The weight of a large catch of fish in the bag is sometimes sufficient to pull the cork line under water, allowing many of the fish to escape. The Japanese prevent this by one man rowing with the skiff to the outer side of the net and supporting the cork line. (Figure 63). He later helps operate the dip-net in landing the fish.

FIG. 76. Bailing the fish from the net. Two boats have come together to load from one successful haul. The men in the skiff dip the fish from the water while two men on each fishing boat hoist the nets on deck and dump them.

The hauling in of the mesh of the bunt continues until the fish are crowded into the landing bag and their weight makes further hauling too difficult. The cork line is drawn up into a circle about ten feet in diameter and partially supported by boat hooks. The fish are then bailed from the net with a large dip-net, dumped on deck, and shoveled forward to make room for subsequent hauls. Three men work together with the dip-net in landing the catch, the others holding the net by sitting on the webbing and spreading the cork line with boat hooks. Often two boats will come together and take their loads from one successful haul (Figure 76).

Preparing for the next haul.

As soon as the catch is landed and disposed of on the deck, the bunt is sometimes roughly washed to remove excess scales and slime, serious tears are temporarily mended, and the wings and bunt piled on deck in preparation for the next haul. It is the practice of most fishermen to circle to the right in laying out the net. When this plan is followed, the left wing of the net is carefully coiled on the port side of the stern, cork line and lead line well separated. The bunt of the Japanese net is piled on top of this, but the bunt of the lampara is piled separately next to the wing so that the whole pile may be thrown overboard at once, avoiding strain on the webbing which might tear the net. The right wing is then coiled to the starboard so that when the skiff is released or the buoy thrown out, the net will pay out freely. On boats which circle to the left, this arrangement of the net on the deck is reversed.

Size of hauls.

The quantity of fish taken in a single haul varies between the many, many weary hauls containing nothing, and the rare streaks of fortune containing over one hundred tons. The capacity of the larger Japanese boats does not greatly exceed twenty-five tons, and when such large hauls are made other boats are called and loaded from the overabundance. During the present season, limit catches of ten to fifteen tons could frequently be taken in one haul, but at times boats whose weary crews had made eight or ten hauls would return from a night's fishing with a ton or even less.

The Fish and Game Commission has legal authority to prevent wastage by limiting the size of the loads according to the tonnage of the boats, for if the fish are piled too deep on the deck, heating and pressure on

FIG. 77. An "idle" moment while waiting to unload. Seine needles are busy with never-ending repairs on the net.

the lower layers renders a large part unfit for canning. During the past season, however, the amount used for canning was small and the surplus was converted into fish meal. The only limits imposed on the catch, therefore, were those required by cannery practices.

Disposing of catch and washing net.

As soon as the night's catch is taken, the run to port is made without loss of time, as the first boat to tie up at the cannery hoist is the first to unload. Most of the canneries start receiving fish at seven o'clock in the morning, but by daylight a long row of loaded boats is tied up, side by side, waiting their turn at the hoist. If the boat gets in before morning, the entire crew will turn in for a few hours sleep on the boat, or if living near the water front, will go home, estimating by the position of their boat in the waiting line the hour to return. But if the boat arrives late and is required to wait but a short time before unloading, the crew sets to work with ever-ready seine needles mending holes in the net (Figure 77).

Fig. 78. Unloading the catch. The fish are shoveled into the hopper where they fall into buckets to be hoisted into the cannery.

The boat is unloaded by shoveling the fish into the cannery hoist with the small net-like shovels described above. The fish from the after-deck space are first unloaded and when these are gone, the ones piled forward along the sides of the cabin are sluiced down to the after-deck with running water from a hose. Six or seven men are able to discharge an average load in about a half hour at canneries using a continuous conveyor, but more time is required where a single bucket hoist is used (Figure 78).

As soon as the boat is unloaded, the deck and deck houses are thoroughly scrubbed with running water and the side boards thrown into the water to remove scales and slime. The boat then backs out of line to allow the next boat to be pulled up to the unloading hoist, and runs outside away from the canneries to wash the net. The pieces of kelp and occasionally gilled fish are carefully picked out of the webbing, and the bunt thrown overboard and dragged through the water for some distance to wash out the slime. The crew then slowly hauls it in, shaking

and sousing the webbing repeatedly to complete the cleaning. Thoroughly washed nets last much longer than carelessly cleaned ones, and thrifty skippers are very particular about the amount of shaking and rinsing their nets receive after each day's work.

Thus it may be seen in following the course of operations, that sardine fishing, even under the mildest and most favorable of natural conditions, entails long hours, heavy labor, and uncertain returns. Only those who are born to following the sea are attracted by the possibilities of fishing, and hence the industry has fallen into the hands of those from foreign lands where fishing is a profession, and not a mere means of living.

CALIFORNIA SARDINE FOOD PRODUCTS AND THEIR PREPARATION.*

By Harry R. Beard.

The outbreak of the World War in 1914 brought about a large increase in the demand for food products. Normal production of most foods require time and the use of valuable raw materials. The world's fisheries, however, were furnishing large quantities of excellent food without such serious drawbacks. Moreover, this supply could be greatly increased and, by using methods of preservation, it could be

Fig. 79. Sardine cannery.

made available anywhere. In addition, the increased quantity of by-products from fish would be of almost equal importance. This is obvious when one considers the things which may be derived wholly or in part from fish wastes. Some examples are: fertilizers, stock and chicken food, glue, oil, glycerine, soaps, explosives, paints, waterproofed fabrics, lubricants, medicinal products, salad oils, butter substitutes, candles, artificial jewels, and ornaments for hats and dresses. Demands for food and for these products naturally led to a vast expansion of the fish industry.

An excellent example of this expansion is shown by the rapid growth of the California sardine industry during the war period. In 1920

*Contribution from Preservation Laboratory, Fish and Game Commission of California, San Pedro.

California's production had risen to a place where it was almost leading in the race for world supremacy. In addition it can be said, that California canneries are second to none in sanitation, equipment, methods of packing, and in the variety and quality of food products produced.

A short description of these products, their preparation and food values follow.

FOOD PRODUCTS.

The sardine packer offers to the trade excellent food products put up in ways various enough to suit any taste. Moreover, most of these products are sold at prices low enough for everybody. The canned products enjoying the greatest popularity are the so-called "pound oval" and "quarter oil" packs.

A can of "pound oval" sardines usually contains four to seven large sized fish which have either been steamed in the can or fried and then packed into a flat oval can with tomato sauce. This is the cheapest and most popular pack put up by the industry.

Next in order of importance is the "quarter oil" pack. Here one finds fried "baby" sardines tightly packed with olive oil into quarter-pound flat cans.

Many other products are put out in smaller quantities. These depend upon the resourcefulness of the packer and the demands of his trade. For instance, the size and shape of the can is varied as well as the size of the fish put into it. Sauces placed in the can include, in addition to tomato, mustard, souse (vinegar and spices), and soy for the orientals. Fancy packs are prepared by making fillet of sardine, by smoking to add the delicate flavor obtained in that manner, by grilling, by packing in glass, and by making mixtures with other foods. Considerable quantities of salted, pressed sardines are sold to the foreign trade.

PACKING.

Sardines are canned in modern packing establishments situated on the waterfront close to the fishing grounds. The size of different plants varies greatly. Some are able to handle only a few tons of sardines a day while others can easily care for 100 tons in the same period of time. The internal arrangement of space and equipment differs in most canneries, yet in each case the arrangement was planned to expedite the process.

Mechanical equipment of the latest type is used wherever possible, making the procedure mostly automatic in the larger plants.

Particular attention is paid to sanitation in all canneries. Cement floors are used to a great extent, as they are easily washed after a batch of fish has been cared for. The fry-baths, trays, and packing tables are cleaned after use by treatment with a solution of soap or caustic soda followed by plenty of water. The women who pack the fish into cans wear white aprons and caps. They are required to keep their hands clean and their nails manicured. Precautions of a like character are required of all personnel who handle the fish.

The methods used in preparation and canning of fried "pound oval" sardines are representative of those generally used in California for preparing most canned sardine products. These methods will,

therefore, be given in detail. Following this description, a few general statements will be made concerning the preparation of steamed "pound oval" sardines and of the other packs which have been described above. In these connections, it is to be kept in mind that the methods given here are subject to considerable variation in the many canneries. These changes, however, are only different means of attaining the same end.

Description of a process is probably made clearer if it is treated according to the steps into which it naturally divides itself. This plan is used here in describing the preparation and canning of the "pound oval" pack.

Preparation and canning of the "pound oval" pack.

Receiving. Sardines are received fresh from the fishing grounds, having been rushed to the canneries to prevent decomposition. They are shoveled from the boats into a mechanical hoist which raises them to an elevated platform where they are weighed. Water and gravity then carry the fish from the weighing vat through a trough into the cannery proper.

Scaling. The first operation in preparing sardines for canning is to scale them. This is accomplished by passing them through a large cylinder of heavy screening, which is rotating in a tilted position. Most of the scales are removed by the rubbing of the fish against each other and against the screen wall of the cylinder. Water is sprayed on the fish at the same time to help remove the scales and to wash the fish. The sardines are discharged on the cutting tables.

Cutting. In at least one cannery in the state an attempt is being made to cut sardines by a specially devised machine. However, this is an experiment. Cutting is usually done by Japanese women. They are paid by the number of buckets of cut fish delivered to the checker, who keeps score by punching a card, which hangs on the cutter's back. Cutting, therefore, develops into a sort of race: each cutter trying to make more money than anyone else. In some cases a cutter makes as high as a dollar and even more per hour when the price paid is thirty to thirty-six cents per hundred pounds of cut fish.

This sort of a race is desirable, as the fish do not tarry long on the cutting tables. In addition, a large number of cutters are employed, so the period only lasts a few hours.

The cutting operation is carried out in the following manner: The fish is taken from the table with one hand and held belly down on the cutting board. One cut with a sharp knife suffices to remove the head and part of the body from the sardine. A sideways motion with the knife removes the entrails and forces all the refuse through a hole in the table. At the same time, the other hand drops the cut fish into the bucket. The refuse from this operation goes to the by-products plant, where the oil is removed and the residue is made into fish meal.

Brining. The cut fish are placed in a large wooden vat containing an almost saturated solution of salt in water. The fish remain immersed in this brine for about thirty to sixty minutes. The time used varies according to the strength of brine, the temperature, and the size of the fish. A man skilled in brining determines when the fish have been brined sufficiently by observing their appearance.

Brining accomplishes several things. Some water, blood, and soluble proteins are extracted. Salt goes in the other direction, penetrating the flesh and making it firmer.

Drying. Brined fish normally contain too much moisture to fry and can well, so the excess is removed by means of hot air.

The apparatus usually used is a tunnel drier. This consists of an elongated chamber, varying from the size of a small, narrow room to

FIG. 80. Sardines coming from the dryer.

the size of a large hallway. Large fans rapidly blow or suck air through a series of steam coils, then through the chamber. In one popular type of drier the sardines pass through the chamber once on an endless wire belt. In their passage they are subject to hot dry air forced down onto the fish by baffle plates. In another type an endless wire belt carries the sardines to the top of the drier and through it. They then fall on a belt traveling in the opposite direction. A set of belts placed one below another repeats this operation several times before the fish leave the drier. In some types belts are not used. Instead of such apparatus, tiers of trays containing sardines are wheeled on trucks into the chamber and allowed to remain until the degree of drying is complete enough.

The time necessary for sufficient drying depends mainly upon: the rate, temperature, and moisture content of the air used, and upon the size of the fish. The time is easily controlled by changing the speed of the belts. Where trays are used the method of control is obvious.

In most cases an hour or less of drying is sufficient. The appearance of the fish is used as a guide in determining the sufficiency of this operation.

Frying. The sardines are conducted from the drier to the fry-bath, where preliminary cooking is accomplished.

Shallow wire trays are partly filled with the dried sardines (if they are not already in trays) and slowly passed through cottonseed oil heated to a temperature ranging from 215 to 240 degrees Fahrenheit.

FIG. 81. Frying sardines.

The apparatus used consists of an elongated metal vat, inside of which is placed, midway of its depth, a horizontal set of steam coils. An endless chain conveyor runs just above the steam coils, carrying the baskets of fish through the length of the bath. Water is added to the bath until it almost comes to the bottom of the steam coils. Enough oil is then floated on top of this water to cover the baskets of fish which are to be carried through it. At times this amount of oil is over a thousand gallons. The temperature is controlled by varying the amount and pressure of the steam which is sent through the coils immersed in the oil.

Frying in pure oil brings out the excellent sardine flavor. In addition, part of the oil is carried on by the fish and this adds to the delicacy of the final product. This operation removes considerable moisture and some soluble extractives from the fish. Part of this water goes off as steam. The rest sinks with the extractives and solid particles coming from the fish. These collect in the layer of water

under the oil. After a day of frying the oil is separated from the water and other waste materials. The bath is then cleaned before the oil is returned to it.

The condition of the fish is used in determining the correct amount of frying. If, after removing the tail and holding the fish in one hand, the backbone can be removed easily and cleanly and shows no uncooked blood, then the process is deemed sufficient. Around eight minutes is the time needed for frying "pound oval" sized fish when the temperature of the oil is close to 230 degrees Fahrenheit.

The trays coming from the hot oil are placed on trucks and allowed to remain there until the fish drain and cool.

Fig. 82. Packing sardines.

Packing. After sufficient cooling the trays of sardines are placed on the packing table where women discard the broken fish and pack the others into clean cans.

The packing table is in a clean, light, airy part of the plant. It is arranged so as to give individual working space to each woman who has a tray of fish and a box of cans within her reach.

The cans come through a chute from a different part of the plant or they are brought in in cases. Each woman has a card which is punched every time she receives a case of cans. This is used as the unit of pay for her work. Some of the women make as high as a dollar or more per hour when the price paid is thirty cents per hundred cans packed.

The women carefully pack the fish into cans and then place them on a belt conveyor which carries them past an inspector, who discards the poorly packed cans. They then go to the sauce distributors.

The steady stream of cans on the belt conveyor passes under a mechanical sauce distributor which adds the correct amount of tomato sauce to each.

Exhausting. When cold sauce is added to the cans they are heated before they are sealed. This is necessary to prevent trouble later. Explanation of this is easily given. Cans sealed cold on a cold day have all empty spaces full of cold air. Later when a hot day comes the air expands and the cans swell. Addition of hot sauce followed by

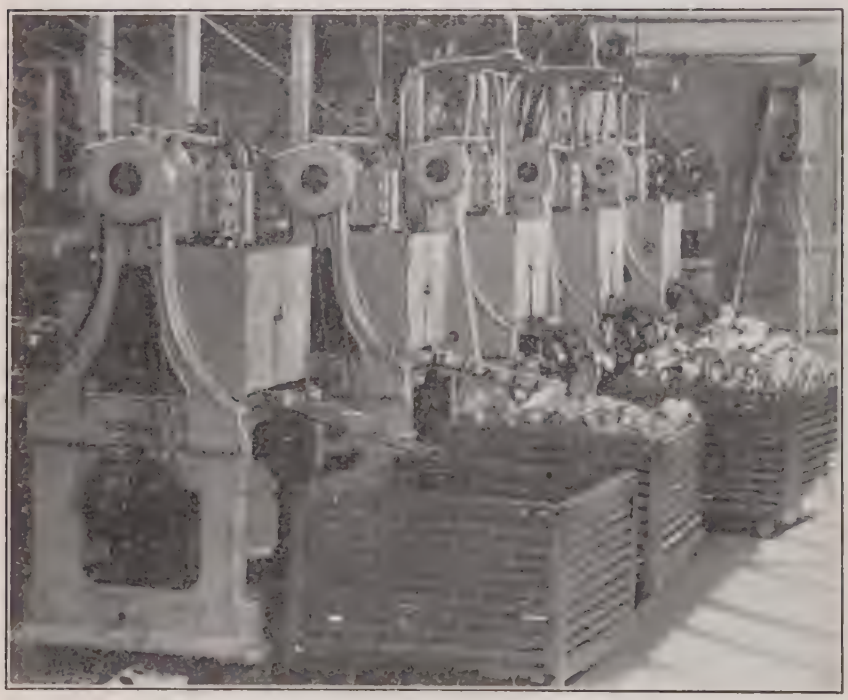


Fig. 83. Sealing cans of sardines.

immediate sealing cares for this difficulty. Another method of accomplishing the same end is to exhaust the cans by heating them after the sauce is added. This is brought about by allowing them to continue on the belt conveyor through a narrow chamber long enough to permit the steam pipes contained therein to heat the contents thoroughly.

Sealing. The cans are carried on the belt conveyor to an automatic sealing machine, which literally picks one of them up, puts a lid on it and with a whirl seals the lid to the can. Some machines do this forty or more times to the minute. The can carries a flange which fits into a groove in the lid having an extended edge bent downward. In sealing, the flange of the can and the edge of the lid are interlocked so as to form a double seam. The groove in the lid carries a very thin

layer of a sort of rubber compound, which serves as a gasket between the seams.

The cans fall from the machine into a large metal truck. This truck, which holds a very large number of them, is made to fit the retort used in processing.

Processing. Sterilization of the contents of the can is necessary to insure its keeping qualities. In addition more cooking is desirable. Proper heat treatment accomplishes both of these steps at one time.

The truck containing the cans from the sealing machine is wheeled into a large steel retort. The door is then tightly closed. Live steam under pressure is turned into the retort. This heats the contents of the cans to a temperature above the boiling point of water. Various

FIG. 84. Processing canned sardines.

temperatures and times are used in this step; however, it is certain that a temperature of 240 degrees Fahrenheit applied for two hours is sufficient. Further, it leaves a margin for safety. The cans are water cooled after processing (or retorting as it is often called).

The high temperature and time used, sterilizes and thoroughly cooks the sardines. Even the bones are made soft and edible.

The cans are next washed in soap solution and allowed to dry. They are then conducted to a room where they go into temporary storage.

Testing. The cans are allowed to remain in temporary storage for about two weeks. At the end of this period each one is examined and those which were not tightly sealed thrown out. These cans are easily

discovered as they have a distorted appearance. They are called "swells." Such condition is brought about by bacteria which enter and act upon the contents. The other cans are then labeled and packed into cases, ready for shipment anywhere.

Preparation of steamed "pound oval" sardines and of other packs.

Steamed "pound oval" sardines are prepared in a manner quite similar to the fried pack. After brining the fish are packed into the cans without drying. Preliminary cooking is accomplished by inverting the filled cans and steaming them. The inverted position permits drainage of the oil and extractives cooking out of the fish. After steaming the same procedure is followed as after frying. This pack can be made more cheaply than the fried one and many people prefer it, too.

"Quarter oil" sardines are prepared and packed in the same way as the fried "pound oval" pack, except for variations in the procedure necessitated by their small size.

Kippered sardines are prepared by placing the fish in chambers where they are treated with hot smoke. This cooks and smokes the fish in the same operation. They are then packed into the cans with or without sauce, sealed, and processed.

FOOD VALUES.

Sardines, like other fish, are excellent food. One could replace all other meats in one's diet by sardines every day in the year and be just as healthy, because they contain as much body-building material and are as readily digested as their more expensive rivals.

A list is given below of important food products having high protein content. The current price of these articles and the food value per pound of each as purchased are included. The food value of the amount of each article which can be purchased for twenty-five cents is given in the last column.

Comparative Costs and Food Values of Some Common Sources of Protein.[1]

Food	Current price	Food value per pound as purchased	Food value purchased for 25 cents
Sirloin steak	35 cents per pound	975 calories	698 calories
Mutton, leg	35 cents per pound	890 calories	636 calories
Ham, fresh	40 cents per pound	1,320 calories	825 calories
Veal, cutlets	40 cents per pound	745 calories	465 calories
Eggs	50 cents per dozen	635 calories	423 calories
Milk, whole	14 cents per quart	310 calories	1,107 calories
Cheese, full cream	40 cents per pound	1,885 calories	1,566 calories
Chicken, broiler	60 cents per pound	289 calories	120 calories
Baked beans, canned	15 cents per 11-ounce can	555 calories	678 calories
Halibut, steak	25 cents per pound	475 calories	475 calories
Salmon, canned	25 cents per No. 1 can	915 calories	858 calories
Tuna, canned	35 cents per No. 1 can	960 calories	643 calories
California sardines, "pound oval," 4 to 7 fat fish per can	25 cents per can	938 calories	830 calories
California sardines, "quarter oil"	20 cents per can	1,101 calories	275 calories

[1]From an unpublished table prepared by Mr. L. D. Elliott of the National Canners' Association Laboratory, San Pedro, California.

Examination of the table shows twenty-five cents to have higher purchasing value for cheese and milk than for "pound oval" sardines. For other articles its purchasing power is lower. "Quarter oil" sardines are even higher in food value per pound than "pound oval" sardines, but they are more expensive. Anyway, they are hardly comparable with the other foods listed as they are classed more as a delicacy than as a staple article of food.

In considering food values it is important to realize that canned sardines are especially high in mineral constituents. Few foods have as high edible content of phosphates and lime as they have. For "pound oval" sardines this value is around two per cent.[1]

[1]From analyses made by the author in the Preservation Laboratory, Fish and Game Commission of California, San Pedro.

INSPECTION IN THE SOUTHERN CALIFORNIA FISH CANNERIES.

Norman Hendrickson, Director, Southern California Fish Investigations, National Canners' Association.

Four years ago in November the fish canners in southern California entered into an agreement with the National Canners Association by which the canners volunteered to submit to a systematic investigation and to abide by rules and regulations to be provided by the association, the cost to be paid by assessment on the cans at the time of purchase. The original contract was for a period of three years. This has expired and a new one has been executed which terminates December 31, 1922. It seems probable that the inspection service will become a permanent institution but that its functions and methods of operation may be varied from time to time to suit the constantly changing business conditions of the industry. Though lacking the authority of a governmental agency, a private institution of this kind is unhampered by direct responsibility to the public and consequent red tape. It can act quickly in any emergency, and need not be as cautious about offering opinions or advice or risking errors in judgment, as is necessary in a public servant. It should be especially serviceable for trying out new projects which are not sufficiently conservative or safe, or which are too closely allied to private enterprise to be undertaken by any public or semi-public agency.

At the time the inspection was established the sardine and tuna industry was growing very rapidly on account of the stimulus given to food production as a war measure. This was responsible for the erection of a considerable number of new canneries and the operation of some of them by men lacking in experience in the canning of sardines and tuna and unfamiliar with the principles involved. The demand for fish was so keen that the fishermen were having things more or less their own way. Prices were advancing and some canners had become rather careless about the quality of fish accepted for canning.

The scope of the inspection in the beginning included a close supervision of the fish from the arrival of the fishing boats until shipment of the final product, and sometimes even further. Every load of fish on arrival at a cannery was carefully examined and passed upon by a competent inspector before acceptance by the buyer. A number of loads were condemned and diverted to reduction plants at a lesser price than would have been paid had they been accepted for canning. This, of course, led to some wrangling and ill-feeling on the part of a few fishermen and inspectors, but the need for such measures was shortlived and all concerned are apparently agreed that they have been benefited by the resultant improvement in the quality of the pack. Excess supplies of fish at any cannery were diverted, whenever possible, to other canneries where there was a shortage, resulting in a considerable saving of food supply.

A close supervision was maintained over the processes involved in the canning, and over the sanitary conditions of the plants, the workers, and the product. A number of invitations have been issued to canners

to clean up certain parts of their plants and equipment. A considerable number of changes in process have also been recommended. Both of the above have been, in all cases, promptly complied with.

A very complete chemical laboratory has been installed and a competent chemist employed. Samples of oils, sauces, and other materials used in sardine and tuna canning are examined before purchase by the canners. A considerable number of instances of adulteration and poor quality in the supplies have been discovered in time to prevent their use by the canners. The time of the chemist, when not employed in testing materials, is devoted to scientific investigation of questions constantly arising relative to canning or the preparation of by-products.

The authority conferred by the United States Food Administration was of very material assistance in enforcing the regulations at the beginning and very extensive use was made of it. Fortunately, before this authority was withdrawn the need for it had entirely disappeared. Both canners and fishermen took very kindly to the regulations as soon as they became familiar with, and accustomed to them.

The most friendly relations with local, state, and federal officials have been enjoyed at all times and have been a wonderful assistance in attaining the desired results without compromising these officials in any way in their official relations.

For two years samples were examined from the daily pack of each canner and certificates issued to such as met the requirements. This issuing of certificates has now been discontinued, partly on account of the expense involved in safeguarding the use of the certificates, partly because the improvement in the pack as a whole makes it less necessary, and partly because there is danger that the issuers of certificates may become partly responsible for the quality of the product. After very careful consideration, all interested are agreed that the responsibility for a product should rest solely upon the manufacturer.

On the whole those in charge of the inspection feel that they have accomplished fairly well the purpose for which the inspection was started. The canneries as a group are quite modern and though there is considerable room for improvement in many of them the state of California has good reason to be proud of them. The quality of the product, the appearance and sanitary condition of the canneries is unquestionably as good as any in the world.

The California sardines of "quarter-oil" size, that is, those packed in olive oil in the familiar small flat tins, lend themselves to the preparation of a very superior article, equal to, if not superior to the best packs of French sardines. The large "pound oval" size packed in various sauces makes an excellent and cheap article of food.

Constant improvements in the handling and packing of the product are being evolved through the enterprise of the canners and the investigations of the various agencies studying the problems of the industry.

NOTES ON THE SEA LIONS.

By Edwin C. Starks.

The sea lion rookery (breeding place) of Ano Nuevo Island seems to be increasing in size, or perhaps it would be better to say, regaining its former size. Whether this is a local or a general increase in number of the sea lions, I have no means of knowing at this time. Neither do I know whether or not this indicates a temporary condition of the rookery; a maximum number, perhaps, of a fluctuation that may have taken place at periods for years without having been commented upon.

An increase of one rookery need not at all indicate an increase among the sea lions in general. It is supposed that the animals always resort to the same rookery, coming back from year to year at the breeding season. If this be so, it would be reasonable to expect a protected

Fig. 85. Ano Nuevo Island rookery, showing cows and pups, Steller's sea lions. Photograph by Edwin C. Starks.

rookery, such as Ano Nuevo is, to increase in size. Certain individuals that bear scars or other marks of identification have been observed to appear at the same rookery year after year.

As further proof of this, and showing what may happen to an unprotected rookery, the conditions of some of the California sea lion rookeries may be cited.* On some of the Santa Barbara Islands several years ago the sea lions, at least the young, were killed for their skins. Sealers landed at the rookeries and clubbed the pups. The most accessible rookeries rapidly grew smaller from year to year, and at last completely ceased to exist as rookeries.

The number of young ('pups') indicate the size of the rookery. Each female ('cow') of breeding age has a single pup each year. Hence

(*Ano Nuevo Island is a rookery of Steller's sea lion.)

each pup on the rookery represents a breeding cow. Each male ('bull') has a 'harem' of from 3 to 18 or 20 cows, or an average, perhaps, of 8 or 10. So by counting the pups on a rookery the size of the rookery may be ascertained with considerable accuracy. This, however, does not take into consideration a more or less indefinite number of individuals not yet breeding ('virgins' and 'bachelors') that are always to be found about the edges of the rookery. But however accurately the number of pups may indicate the entire size of the rookery, they certainly may be used as an accurate index to the fluctuations in size of the rookery. As the pups, until they are a month or six weeks old, do not leave the rookery when the adults are frightened away, they may be counted with considerable ease and exactness.

I spent several days at various times on the Ano Nuevo rookery in the years 1901 and 1902. The rookery was then confined to either one

FIG. 86. Steller's sleeping pups. Adults in the distance. Ano Nuevo Island rookery. Photograph by Edwin C. Starks.

of two outlying rocky islets, known as Flag Rock and Sea Lion Rock, respectively. It was then a rookery of about 150 pups. Stories were current, however, of how in former years the rookery was much larger and not only covered the two outlying rocks, but also a part of the main island.

I recently (June 25, 1921) visited the island and found the latter condition. Both Flag and Sea Lion rocks were occupied and there was a considerable overflow onto the main island. I was informed that the number of pups at the last count (last year) was about 500.

The desirability of thinning out the sea lions is being continually brought up by the fishing interests. Before such a course is thought of, it should be ascertained with great certainty whether the sea lions are increasing or diminishing in number. Even if an increase is found, it should be made certain that it does not indicate a more or less normal fluctuation. If it can be proved that there is a steady increase, the animals may well be kept down to reasonable numbers.

This may most easily be done by killing a predetermined number of the pups on the rookery and carefully watching results. Shooting the

adults from a boat when they are in the water is uncertain, cruel and wasteful. One never knows the percentage of wounded animals, for when shot they usually sink at once. The young nurse for the greater part of the year, so killing a cow usually means the slow starvation of her pup. In killing the pups on the rookeries the skins may be saved.

If nearly any sort of animal were thinned in number, one might naturally suppose that, if there were left a few of each sex of that animal, it would in time increase until it regained its former number. Such does not always appear to be the case. Often when an animal reaches a certain low level in number, it seems unable to recover, but becomes extinct. Hence the question of thinning out the sea lions should be approached with extreme caution. There is an intricate balance maintained between animals that seldom can be disturbed

FIG. 87. Steller's sea lion, after being frightened from the rookery, Ano Nuevo Island. Photograph by Edwin C. Starks.

with impunity. Aside from purely sentimental reasons for wishing to preserve the sea lions on our coast, it may develop in time that they have as much value as many other products of the fisheries.

It may be pointed out in this connection that the cormorants, shearwaters and other sea birds, keep themselves pretty well gorged with fishes. As there are thousands of these birds along the coast, the total number of pounds of fishes per year that they consume must amount to considerable. But no one, I hope, will want to, or be allowed to, kill the sea birds on this account. The leopard seal is surely equally as great a fish eater as the sea lion, as are also the several porpoises. Sharks, too, may well cause much of the damage that the sea lions are blamed for. Lastly, destructive methods and waste in the fisheries may well receive consideration for depleted fisheries.

The sea lions of both species deserve study. A census should be made of the rookeries from year to year. Though the number of pups on the California rookeries indicates the number of sea lions on the coast at the breeding season, it is not at all certain that it indicates the number for all of the year.

Steller's sea lion breeds from the Santa Barbara Islands northward into the Arctic Ocean. The California sea lion breeds from the Santa Barbara Islands southward to some point on the Mexican coast. It is supposed that there is considerable migration among them, but there is no very good direct evidence of this. It may be, for instance, that the animals from Alaska spend a part of the year on the California coast. At any rate it is known that the California sea lion, that does not breed north of the Santa Barbara Islands, migrates at least as far north as the Columbia River.

FIG. 88. Steller's cows and pups on Ano Nuevo Island rookery. Photograph by Edwin C. Starks.

The fur seals, that are rather closely related to the sea lions, breed only in the Arctic Ocean, but they migrate southward along our coast, and have been killed in former years on our mainland, and within my own memory on the Santa Barbara Islands. As the sea lions have many of the habits of the fur seals, we may argue that they, too, migrate from the place they were born. We do not know how far north the California sea lion extends its range, nor how far south Steller's sea lion goes.

Though a census of the California rookeries may not show the number of sea lions that may visit the coast, nevertheless such a record should be kept from year to year if only to show the number born on the coast and to preserve important data for future study of the life history of the animals.

Pups should be marked or branded with a distinctive mark for each rookery, and records made of the subsequent movements of such marked individuals. Thus it may be known whether animals born on one rookery ever breed on other rookeries. By this means, also, the extent of migrations could in time be learned. By a system of marks changing from year to year, the approximate breeding age as well as the entire age could be ascertained.

A DISTRIBUTIONAL NOTE ON HALIOTIS.

By S. Stillman Berry.

In his useful paper on "The Abalones of Northern California," in Volume 6 of this journal, Thompson ('20, pp. 45, 50), while recording the northern green abalone (*Haliotis walallensis* Stearns) from Monterey, a station which a small, rather poor specimen in my own collection apparently confirms, is inclined to reject the Alaskan white abalone (*H. kamtschatkana* Jonas) from the California list. However, a small form of it does undoubtedly occur at least as far south as Monterey Bay. Cooper, who states that he picked up a single dead shell on the beach at Monterey, affirmed this half a century ago ('70, p. 61), while another dead shell dredged by me in 15 fathoms, off Monterey, in 1906, was recorded some years ago (Berry, '07, p. 46) as *H. gigantea*, authorities differing then, as they still do, as to whether *kamtschatkana* and *gigantea* are practically separable. Present reexamination of the specimen does not cause me to alter this opinion of its identity.

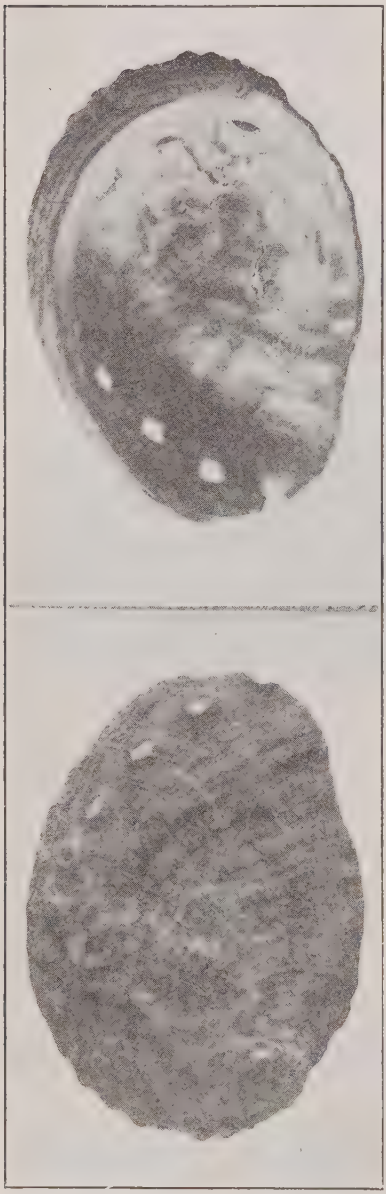


Fig. 89. *Alaskan white abalone* (*Haliotis kamtschatkana* Jonas), from Monterey Bay, California. Natural size. Photographs by S. S. Berry.

On a recent visit to Monterey, Mr. Carl Dolter showed me a small series of dead abalone shells which he had picked up along the sandy shore just north of Del Monte. All proved to belong to this northern species. One of these, which Mr. Dolter kindly gave me, and which is here figured for the sake of completing the valuable series of illustrations given by Thompson, is practically perfect, and measures, length 61.5, width 44.0, height (est.) 17 mm. None of the specimens is in any way commensurate with the ordinary Alaskan examples. *H. kamtschatkana* is far and away the smallest known species of California abalone.

Other authorities to record the Alaskan white abalone from Monterey have been Carpenter ('64, p. 541) and Campbell ('91, pp. 103, 104). Quite recently Dall ('21, p.

184) has recorded *H. kamtschatkana* from as far south as Redondo, but throughout this paper credence is unfortunately given to many poorly authenticated or doubtful extensions of geographic range, so that even where they seem perfectly reasonable, it would be easy to show too much precipitance in copying them until the supporting data can be placed on record.* Incidentally it may well be mentioned that the taxonomic recognition of no less than twelve Californian abalones in this paper is a little misleading to the general reader, for at least two of the subspecies of *H. cracherodii* there recognized are based upon characters which seem certainly pathologic (*holzneri* Hemphill and *imperforata* Dall), while the other two are likewise of extremely uncertain value racially. Eight distinct forms of *Haliotis* is the only safe maximum we can claim at the present time.

H. kamtschatkana has figured but scantily in the literature of our fauna, and although by no means the rarest, is one of the least known of all our species. By all odds the best available account of it is that of Thompson (:14), which concerns itself mainly with the economic aspects of this mollusk in British Columbia. Over much of the western coast of North America it is the only discovered species of abalone.

*Carpenter's record of the species from "near San Pedro" ('64, p. 541) is equally doubtful, but perhaps can never be certainly confirmed or rejected. His record of it from the Farallone Islands (op. cit., p. 651) is probably safer.

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A SELECTED BIBLIOGRAPHY OF CHEMICAL LITERATURE PERTAINING TO THE FISH INDUSTRY.

By Harry R. Beard, Preservation Laboratory, Fish and Game Commission of California, San Pedro, California.

This laboratory's cooperation with the California fishing industry has shown the need of a selected list of recent references for chemists in this industry who have neither the time nor facilities for making an exhaustive search of the literature bearing on their work. The following list was assembled as an endeavor to meet this need and to furnish a foundation for a more complete working bibliography. It is hoped that publication will extend its usefulness. The references cited were selected from a much larger list collected in a search of Chemical Abstracts, U. S. Bureau of Fisheries' publications, reference works and papers on the subject. The attempt was made to cite only a very few articles which appear in standard reference works or which appear in bibliographies given as a part of articles listed here. The publications of the U. S. Bureau of Fisheries have purposely been omitted, except in a few instances. The annual reports of the Commissioner of Fisheries contain a wealth of excellent material, any part of which can now be found easily by consulting the subject index, the title of which is given as the last reference in the list.

Although prepared primarily for technical men, the list will be found to be equally useful to others.

The importance of the foreign references, coupled with the lack of American articles, made their inclusion advisable.

Much credit is due Mr. Harden F. Taylor of the U. S. Bureau of Fisheries, Washington, for his criticisms and additions.

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*The Division of Fishery Products, U. S. Bureau of Fisheries, Washington, issues a series of memoranda on the capture, preservation and utilization of fishery products. These memoranda, copies of which can be obtained upon application, contain a wealth of information. Number S200 of this series gives the titles of the numbers issued to June 1, 1921.

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All material for publication should be sent to **H. C. Bryant, Museum of Vertebrate Zoology, Berkeley, Cal.**

December 12, 1921.

A SARDINE NUMBER.

Commercial fisheries in California first came into prominence in early days with the salmon industry, which was the first fishing industry of any importance in the state. Then developed the tuna industry, and in the last few years the sardine industry has come to be recognized as the most important of the fishing industries. These fisheries mean an annual return to the state of many millions of dollars. The total pack of all varieties of fish canned in 1920 was about 1,941,984 cases. In view of the constantly growing value of these industries, and the part played by the Fish and Game Commission in their development, we are issuing this "Sardine Number." The excellent and well illustrated articles on the sardine industry, methods of catching and of canning, and of the various uses for these fish and their by-products, have been prepared by the staff of the State Fisheries Laboratory, and are designed particularly for those readers who are interested in fisheries in general. Nevertheless, they should prove of value to the trade because of statistics which appear in print for

FIG. 90. Chart showing comparison of sardine catch in California, years 1916 to 1920. Prepared by S. H. Dado.

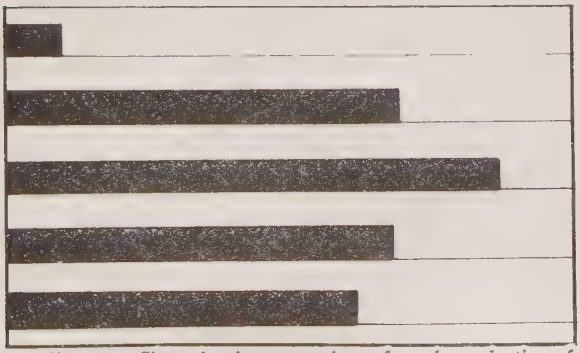

FIG. 91. Chart showing comparison of yearly production of California canned sardines. Phepared by S. H. Dado.

the first time. The accompanying diagrams (Figure 90 and Figure 91) will show the rapid growth of the industry, and the yearly production from 1916 to 1920.

COMPARISON OF SARDINE CATCH.

The United States Bureau of Fisheries has furnished us with a comparison of the output of the sardine fisheries of Maine, Norway, Portugal, and France, together with the relative number and value of the plants, the number of employees, the total quantity of fish caught, and the quantity of sardines caught, the quantity canned, and the value of the sardines. A glance at the following table, covering the year 1919, will show how the output and value of the California industry compares with that of the other countries:

Comparison of the Catch of Sardines for the Year 1919.

	California	Maine	Portugal	France	*Norway
Number of plants	41	[1]52			
Value of plants	$7,708,871	[2]$3,680,248			
Number of employees	8,242	5,457			
Quantities of fish, lbs.	262,260,000	[3]123,940,635			
Quantities of sardines, lbs.	153,880,000			[4]16,688	[5]185,515
Quantities canned, cases	2,071,641	2,426,132	[6]39,264		
Value of sardines	$11,813,156	$843,463	[7]21,329,695	[8]37,086	

*Commercial report, November 21, 1919 for 1916.
[1]Sardine plants.
[2]Sardine.
[3]Herring and sardines.
[4]Metric tons (16,718.83 long tons).
[5]Metric tons (182,575.55 long tons) exported.
[6]Tons.
[7]Escudos.
[8]Francs.

SUMMER RESORT EDUCATIONAL WORK, 1921.

Continued along the same lines as last year, the Yosemite Nature Guide Service reports increased interest on the part of the public and improved service rendered visitors to Yosemite National Park. That the Fish and Game Commission, cooperating with the National Park Service, has taken advantage of the opportunity to teach natural history and fish and game conservation to summer vacationists is evidenced by the following figures: Attendance at the 52 illustrated lectures and campfire talks given totaled 31,545. Attendance on the 105 field trips given totaled 2214. All day field trips numbered five. Innumerable questions were answered during the office hours. Increased interest in the field trips offered is reported, the numbers in attendance on several occasions exceeding fifty. Splendid opportunity of bringing home conservation lessons was afforded on the field trips by first hand study of trout, deer, tree squirrels, grouse, mountain quail, and band-tailed pigeons, as well as the common song birds. That this educational campaign will react favorably on the development of a useful sentiment as regards the conservation of natural resources, appears inevitable.

STATE FAIR EXHIBIT, 1921.

The general consensus of opinion by visitors to the State Fair (September 3–11) was that the Fish and Game Commission's exhibit was "the best thing on the grounds." It was so well advertised by enthusiastic visitors that practically everyone entering the gates saw the display. Three years ago the Commission installed a permanent exhibit consisting of a panorama of the Sierra Nevada showing three of the state's hatcheries in miniature and lighted in such a way as to give the changing colors of sunset, night and sunrise. Pleasing additions were made this year in the form of Mount Lassen in eruption and a small electric train that formed a special attraction to the children. The floor space was nearly doubled by the addition of a well arranged exhibit by the Commercial Fisheries Department. The increase in the fishing industry was graphically shown and fishery products of all kinds from abalones to tuna were on display. Equipment for whale fishing and abalone fishing were particularly enjoyed by the crowds, as

FIG. 92. Field study class in Yosemite, 1921. Nature walks are part of the summer resort educational program of the Fish and Game Commission. Photograph by H. C. Bryant.

were also the materials manufactured from kelp. Educational films shown twice daily attracted large crowds also. Through the medium of this exhibit many thousands of people have become intimately acquainted with the work of the California Fish and Game Commission.

HUNTING ACCIDENTS.

With the opening of the deer season came the usual number of hunting accidents. One San Francisco hunter was critically hurt in Trinity County when a companion mistook him for a deer, a professor at Stanford University was seriously wounded near Redding, and another man met death at the hand of his hunting companion near Gilroy under similar circumstances. Several other accidents of the same kind might be cited. There should be less danger in going hunting than in traversing rattlesnake country, and yet it is quite the reverse. It is very doubtful whether one man a year dies from the bite of a rattlesnake, and yet anywhere from five to fifteen hunters lose their lives annually. The only excuse that a hunter has who kills his companion is "carelessness," if that can be considered an excuse. Certainly it is not a satisfactory excuse! The spiked buck and doe law has been found helpful in decreasing hunting accidents. This is the state's contribution. The thing now needed is the following of the "look before you shoot" motto by the individual hunter.

PUBLIC SHOOTING GROUNDS.

The usurpation of most of the best wildfowl shooting grounds by gun clubs has caused increased demand for public shooting grounds. Although the desirability of such public shooting grounds appears to be admitted by both state and federal officials, the first real attempts to secure them have only recently appeared. Included in the New-Anthony bill is provision for the purchase, or rental, and maintenance of marsh and water areas especially suitable for migratory wild fowl, which shall be used as free public

shooting grounds in the open hunting season and safeguarded as breeding and resting places for these birds in the close season; and second, the administration of the migratory bird treaty act in order more adequately to maintain and increase the supply of migratory birds, including not only the ducks, geese, and others classed as game, but the great host of smaller species which are so vitally essential to the agricultural interests of the country through their unceasing war on injurious insects.

The most needed step at present is the conservation and perpetuation of a sufficient number of small inland lakes, as well as inland and coastal swamp and marsh areas, to provide our migratory wild fowl necessary feeding, resting, and breeding places within the United States. Many of them should at the same time be set aside as public shooting grounds. Under proper conditions many lakes, ponds, swamps, and marsh areas will yield a distinctly larger return than would the same areas drained for agricultural purposes.

Louisiana is one of the first states to adopt the broad policy of protecting its citizens against monopolization of the desirable hunting grounds by exclusive clubs. In the setting aside of the Pass-a-l'Outre Public Shooting Grounds, a tract of 60,000 acres at the mouth of the Mississippi River, the first public shooting grounds have been established. Here the sportsman of moderate means can enjoy all the opportunities for wildfowl shooting enjoyed by wealthy members of the exclusive clubs in that region.

UNNATURAL NATURAL HISTORY.

Much of the misinformation which prevails among the general public can be traced to the false reports published in our prominent newspapers. We sometimes read of the attacks of mountain lions upon people passing their haunts; or of the attacks of eagles or other large birds upon children and grown people. These stories, when traced to their source, are usually found to be entirely without foundation of truth. Nevertheless, the prejudice left in the minds of those reading such stories is leading to the destruction of many of our large birds, which are fast disappearing and yet are a relatively harmless species.

For example, our attention was recently called to the following item, which appeared in the *Oakland Tribune* of June 8, 1921:

EAGLE KILLS BOY WHO CLIMBS TREE TO LOOK AT NEST.
(By Associated Press.)

Ventura, Cal., June 8.—Juan Gonzales, 11, was killed by an eagle on a stock ranch twelve miles north of here last Sunday, it was announced in a report received today. The boy climbed a tree to look at the bird's nest and was attacked before he could escape. His skull was punctured in three places by the bird's beak.

After reading this item, Mr. Emerson A. Stoner, of Benicia, California, undertook an investigation of the story, and received the following letter from Mr. Lewis P. Hathaway, the Coroner and Public Administrator of Ventura County:

Ventura, California,
June 10, 1921.

Mr. Emerson A. Stoner,
Box 444, Benicia, California.

Dear Mr. Stoner: Regarding the story of the horrible work of eagles in Ventura County, will say:

On June 1, a Mexican employed on Ranch Sespe between Fillmore and Santa Paula appeared at the office of Dr. Merrill in Santa Paula with his little son who was ill; had been ill for some time. Dr. Merrill informs me that in taking the "history" of the case, he asked the parent or parents if the lad had suffered injury within the past few weeks. They said the only chance he had had of being injured was when he fell from a tree several weeks ago; blackbirds had flapped about his head when he attempted to interfere with their young, and, frightened, he had fallen a short distance.

Dr. Merrill made an effort to locate bruises or breaks, but it was not until he had bathed the lad and shaved his head for the removal of cooties, that he could determine as to outward appearances; he informs me there were NO bruises and NO "holes in the skull," or even in the scalp, or indications that there had been any.

The illness was then diagnosed as "peritonitis," because, the possibility of outward injury eliminated, this seemed the only result that could be arrived at.

The lad died on June 2, and the death certificate was "peritonitis."

All of these statements were corroborated by my deputy at Santa Paula, Mr. E. A. French, who is an undertaker. It had not occurred either to Dr. B. E. Merrill or undertaker E. C. French that there was necessity (?) for a notification

of the coroner until the newspaper at the county seat published the "eagle story."

A Spanish vaquero heard the blackbird end of the yarn, proceeded to imagine the wounds on the head, and the business manager for the vaquero's employer brought the embellished story to Ventura. It needed further embellishment and a willing newspaper reporter did the rest.

Interesting, isn't it?

The yarn was only a yarn.

Yours very truly,

(Signed) LEWIS P. HATHAWAY
Coroner.

MIGRATORY BIRDS IN LATIN AMERICA.

Dr. Alexander Wetmore, who has recently returned from a year's absence in Argentina, Paraguay, and Uruguay, has collected some valuable material regarding the status of the North American migratory birds in the countries which he visited.

Among the migratory birds which Dr. Wetmore found in South America was the barn swallow. Other species noted were shore birds which were observed in the marshy pampas or on the coastal mud flats: "Some were found to winter well north in the Tropics and others to travel as far south as the Straits of Magellan. Among our game birds seen in Argentina and elsewhere were the golden plover and pectoral sandpiper."—*Weekly News Letter*, United States Dept. Agr., August 3, 1921.

One of the objects of Dr. Wetmore's trip was to secure information regarding the possibility of arranging treaties with the South American countries for protecting migratory birds, similar to the Migratory Bird Treaty Act which the United States has with Great Britain. When we consider what the protection of migratory birds has accomplished in North America, as recognized by both scientists and sportsmen, we feel that it would be a splendid attainment if their protection could be further extended to this southern country.

RAINBOW TROUT ACCLIMATIZED IN AUSTRALIA.

As has been stated before in these pages, the rainbow trout has become well established in New Zealand and also in Australia. We present herewith (see Figure 93) some visible proof in the way of a photograph of a catch of rainbows made on the Deepwater River, New

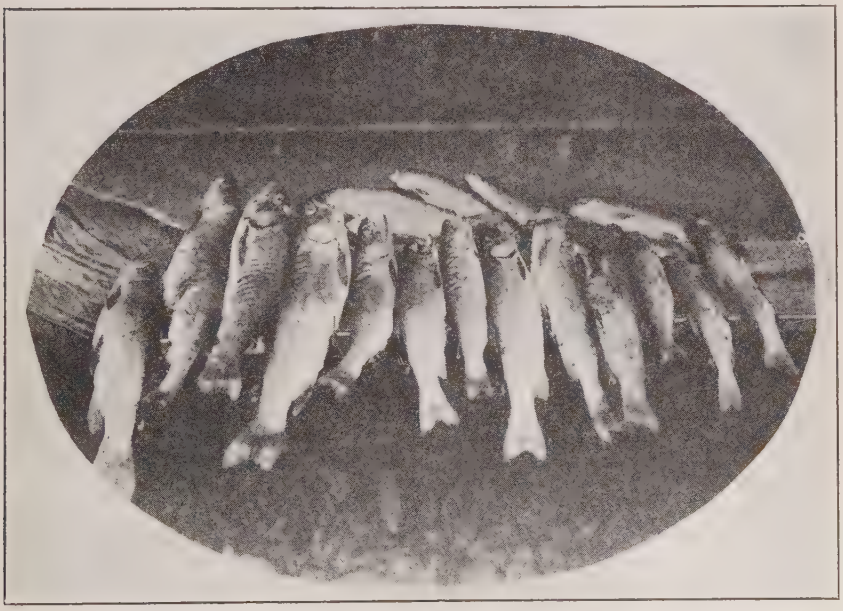

FIG. 93. Catch of Rainbow Trout made on Deepwater River, New South Wales, by Mr. J. S. Bacon. Photograph by J. S. Bacon.

South Wales. Mr. J. S. Bacon, who sends the photograph, states that the fish are doing well and breed successfully.

California's rainbow is now widely distributed over the world from Australia to the Argentine. The golden trout is now in demand and the question is: Shall we let the world have it or keep it a distinctive fish in California?

AUSTRALIA SEEKS INFORMATION ON FISHWAYS.

That Australia is confronting the same problem with reference to migratory fish occasioned by the development of irrigation systems that California successfully solved several years ago, is evidenced by the following letter received from Hon. F. Lewis, Chief Inspector of Fisheries and Game, Melbourne, Australia:

From the frequent perusal of your splendid journal, "California Fish and Game," I note that the provision of fishways or ladders is compulsory in your state. Many large dams and weirs have been erected on our water courses during the last few years with a view to conserving water for irrigation purposes, and this work will probably extend very considerably in the near future.

So far no fishways or passes have been erected on any of these weirs, although many of the streams are stocked with both brown and rainbow trout. In addition there are large numbers of native fish, mostly members of the perch family, in these waters. As it is very desirable to allow facilities for the natural movements of the fish, I shall be grateful if you can let me have full particulars of the law in operation in your state relating to the erection of fishways or ladders. I should also like to have any plans or photographs available of such works.

Are the fish ladders only erected on streams where trout are found, or must they be placed on all waters irrespective of the class of fish contained therein?

Full details regarding legislation, construction and maintenance of fishways have been sent the Australian official.

NEW BIRD LAW PROHIBITS GUIDES FROM MAKING KILL.

A tendency to tighten the restrictions on the hunting of birds and big game is noted in the game laws for 1921, a summary of which, both federal and state, has been compiled by the Biological Survey of the United States Department of Agriculture, and published as Farmers' Bulletin 1235. Among the notable changes made during the present year was the amending of the Migratory Bird Treaty Act regulations with respect to bag limits.

This amendment provides that the daily bag limit of any person shall now include "all birds taken by any other person who for hire accompanies or assists him in taking migratory birds." This will put an end to the abuse of privileges under the regulations regarding the prescribed daily bag limits by persons who claim that birds were killed by guides accompanying them.

The federal waterfowl season for California was fixed from October 1 to January 15, replacing the old season of October 16 to January 31, the season now being the same under both federal and state laws. Regulation 9, governing the issuance of federal scientific permits, was amended to permit the issuance of limited and special permits.

State legislation harmonized federal and state laws on waterfowl and shore birds in Kansas and Oregon, and on waterfowl in Pennsylvania and Rhode Island; Washington prescribed a statewide open season on all migratory game birds from October 1 to January 15, thus deviating from the federal regulations, which supersede the state law, east of the Cascade Mountains, where it will now be possible to hunt migratory game birds only from October 1 to December 31, without violating either federal or state law; in Idaho the open season on migratory game birds has been shortened under state law two weeks by opening October 1, instead of September 16, and extending to December 31.

Idaho, Kansas, Montana, Nebraska, Oregon, and Washington enacted legislation similar to the federal regulation prohibiting hunting from airplanes. Colorado reduced the bag limit on ducks from 20 to 15 a day, while Kansas increased the limit from 20 to 25. In New Jersey reedbirds were protected at all times by being placed in the nongame class. The open season for woodcock was shortened 25 days in Michigan, two weeks in New York, and one month in Vermont. Doves were protected until

1924 in Colorado, and in Kansas an open season on them was provided from September 1 to October 15.

In general, seasons on big game were shortened and hunting further restricted. Buck laws were enacted in Michigan, Montana, Nevada, North Dakota, South Dakota, Vermont, and in Washington east of the Cascades. Maine protected spike bucks and prescribed that one of the two deer allowed in the eight northern counties must be an antlered buck, and provided that in two of the counties only residents may hunt deer during the last two weeks of the open season. Bull moose were protected for five years in Maine.

The summary of the laws contains the provisions relating to seasons, licenses, limits, possession, sale, and export, thereby furnishing the reader a brief and convenient synopsis of the laws of each state, territory, or province of Canada. The migratory bird treaty, the treaty act, and regulations, as well as the Canadian regulations also are appended. Copies of the bulletin, Game Laws for 1921, may be had free upon application to the United States Department of Agriculture, Washington, D. C.

WIRE HALTS BEAVER.

A barbed wire entanglement which will keep beavers from destroying property and constructing dams has been tried out by the state fish and game authorities at the A. M. Kischir ranch in the Shields valley with so much success that it is believed that it will no longer be necessary to grant any considerable number of permits to kill beaver in Montana.—*Billings Gazette*, July 15, 1921, Montana.

A SEA ELEPHANT NEAR SAN CLEMENTE.

The issue of *The Catalina Islander* of September 20, 1921, records the occurrence of a sea elephant between San Clemente and Catalina Islands on September 10, by Captain Hugh MacKay, Mr. Mankowsky and party in the launch Manana. Two interesting photographs are shown.

FACTS OF CURRENT INTEREST.

The Fishcultural Department reports that the past year has been a most successful one. Of trout fry alone there were reared and planted nearly 25,000,000.

An old violator was caught with 28 ducks during the early part of September, by Deputy Carpenter. A stiff jail sentence followed.

The Sacramento office has made several Greeks and other aliens put a higher valuation on citizenship by haling them into court on their failure to produce citizenship papers, although carrying resident hunting and fishing licenses.

The Fish and Game Commission's exhibit at the State Fair, during the first week in September, attracted wide interest. The usual display of golden trout was made, no difficulty being found in keeping these beautiful fish on display.

During the summer more than 31,000 persons heard lectures and campfire talks on wild life and its conservation in Yosemite National Park and more than 2000 availed themselves of the opportunity to go afield under a nature guide.

The kelp industry, which grew to importance during the war, is now a memory, all the plants having closed down.

NOTES FROM THE STATE FISHERIES LABORATORY.

WILL F. THOMPSON, Editor.

THE NEW LABORATORY.

This month, September, sees the practical completion of the new laboratory, regarding which an article appeared in the last issue of this magazine. It promises to exceed all our expectations in beauty and convenience, although not too large for efficiency. It is fully expected that the middle of October will see us installed in our new quarters.

THE ALBACORE SEASON.

The albacore season has been unexpectedly successful, there having been taken, according to recent estimates, nearly eight thousand tons. Considering the lateness of the start, which was due to difficulties over price, the catch has been relatively successful. The season has been characterized by a remarkably late run at the Coronado Islands.

At the present writing considerable numbers of yellow-finned tuna and skipjack have appeared. Also numbers of the smallest year group of albacore have been taken, as was the case last year. But no frigate mackerel, dolphins or other unusual fish have come into the wharf as yet. And above all, the blue-fin tuna have been noteworthy for their absence, where in previous years so many have been taken.

THE LABORATORY STAFF.

During the past three months Mr. Sette and Mr. Holmes have both been at San Pedro, but leave September 26 for Monterey, whence they go to Stanford University on the twenty-ninth for the fall term there.

Dr. Tage Skogsberg has been employed to take Mr. Holmes' place during the coming year. Dr. Skogsberg is a graduate of Upsala University, Sweden, and came to this country in order to pursue his studies on ostracods. After residence for some time at Hopkins Marine Station, at Pacific Grove, he sought permanent employment in this country, rather than to return to Sweden. The Commission was grad to obtain him, as men of his qualifications are hard to obtain.

In the place of Miss Helen Edwards, now Mrs. Bacon, whose marriage was chronicled in the last issue of this magazine, we have been fortunate in securing Miss Frances N. Clark. Miss Clark is a graduate of the Zoology Department of Stanford University and has had much experience in assisting Dr. C. H. Gilbert and others in their work on the salmon. She will have charge of the library work in the new laboratory, as well as assisting Mr. Thompson.

Mr. W. L. Scofield has been stationed at Monterey, as previously, carrying on the sardine investigations there.

Mr. Thompson and Mr. Higgins are at San Pedro in anticipation of the opening of the new laboratory. They attended the meeting of the American Association for the Advancement of Science, with which the Pacific Fisheries Society is affiliated, and Mr. Thompson read a paper on his albacore work.

THE SURF-SMELT, HYPOMESUS.

On June 28, Mr. Thompson visited Halfmoon Bay with Mr. Scofield and Mr. Dado, in order to study the run of the surf-smelt, *Hypomesus*. Unfortunately no smelt ran and inquiry was restricted to conversations with experienced fishermen and observation of the beaches on which they are said to run.

It is clear, however, that there are no grounds as yet for supposing that the species spawns on the beach, or even that it spawns in the surf. It is said to be found at irregular times, and sometimes on one beach, sometimes on another. The fishermen with whom we talked could not foretell in any way when a run would occur, and the fish were supposed to appear any time between April and September. The fact that they were usually taken on a beach with a net did not, of course, prove their absence on rocky shores.

The fishermen said anchovies were sometimes taken the same way, at night.

THE LIBRARY.

The California State Fisheries Laboratory has recently acquired the following complete sets:

Journal of the Marine Biological Association of the United Kingdom.

Report of the Lancashire Sea Fisheries Laboratory of the University of Liverpool.

Report of the Liverpool Marine Biological Committee.

Memoirs of the Liverpool Marine Biological Committee.

Transactions of the Liverpool Biological Society.

Meddelelser fra Kommission for Havundersogelser. Series: Fiskeri, Hydrografi and Plankton.

International Revue der gesamten Hydrobiologie and Hydrographie.

Norsk Fiskeritidende.

The Sea Fisheries. J. Travis Jenkins.

Publications of the Conseil Permament International pour l'Exploration de la Mer.

A NOTEWORTHY BOOK.

The library is recently in receipt of a volume, "The Sea Fisheries," by Dr. J. T. Jenkins. It describes the fisheries of England, their administration, methods and scientific investigations in as comprehensive a manner as possible within a good sized volume. It is carefully compiled, in a scholarly fashion, and the content is not marred by unduly emphasized viewpoints. The fact of depletion is stated with proper emphasis, and without distortion of evidence.

In only one particular does the author disappoint to a serious extent, and that is in his avoidance of critical treatment of research work, particularly other than England.

The book is decidedly necessary to any fisheries library, however limited in

scope, and may be obtained from the author, 16 Walton's Parade, Preston, England, at 24 shillings net, postage 1 shilling.

RARE FISH TAKEN AT SAN PEDRO.

During the past summer a brief inquiry into the usage of common names of the commercial fishes at San Pedro was started to aid in the proper interpretation of the statistical returns of the fishery. This entailed regular trips to the markets by the members of the laboratory staff and a close scrutiny of all doubtful species. In this way ninety-three separate species in the commercial catch have been recognized and their common names noted. A few of these being rare in this locality are worthy of mention.

Among surf-perches (Embiotocidae), few of which are distinguished by the dealers except as "white-, black-, and blue-perch," were several species of especial interest. *Phanerodon atripes*, which to our knowledge has never been recorded south of Monterey since Eigenmann's specimen from Cortez Bank, was represented in our collection by one specimen. *Rhacochilus toxotes*, said to be rare in this locality, was seen by us rather commonly. *Damalichthys argyrosomus*, though common northward, was found occasionally in June and September.

Of the forty species of rockfish or "rock cod" (*Sebastodes* sp.) taken on the California coast, twenty-eight have appeared in the San Pedro markets during June and July. Only two of these species occurring most commonly have well known common names, the bocaccio (*S. paucispinis*) and the chilipepper (*S. goodei*). Many fishermen distinguish between the different species, using names of their own invention, but there is little uniformity among them. Thus, *S. mineatus*, one of the most abundant species, is often called "red rock cod" and sometimes "salmon grouper," although the latter is also applied to *S. goodei*. *S. levis* is called "Harry Olesen" by some, and *S. chlorostictus* is the "chucklehead." The three small, dark-colored species, *S. atrovirens*, *S. serranoides*, and *S. rastrelliger* are frequently confused with the rock bass and included with them in the markets. All the other species are lumped together as "rock cod," by the fishermen, and this practice is extended by the marketmen to include all the rockfish.

The rarer species encountered during the summer are here listed. Two specimens of *Sebastodes cos* were taken at San Clemente I. in June, and several have since been seen in the markets. This species was reported by Eigenmann in 1892 as abundant at times at San Diego, but it has rarely been seen by naturalists since that time.

Two specimens of *Sebastodes gilli* also were taken in July. The occurrence of this species has not been recorded since the original record by Eigenmann in 1891, and it is known only from the types taken at Point Loma.

A specimen of *Sebastodes introniger*, another rare species, was taken at San Nicolas I. during June in eighty fathoms of water. It is one of the deeper water rockfishes and the few specimens known have been taken in Alaska in from 85 to 350 fathoms, on the coast of Washington, and in southern California waters in depths from 178 to 369 fathoms.

Sebastodes ovalis. another rockfish formerly supposed to be quite rare, has occurred in small numbers in the markets on several occasions during the summer. —E. H. and O. E. S.

REPORTS.

VIOLATIONS OF FISH AND GAME LAWS.
April 1, 1921, to June 30, 1921.

Offense	Number of arrests	Fines imposed
Game.		
Hunting without license	6	$95 00
Ducks (wild)—closed season—possession or hunting	3	25 00
Deer meat—closed season—possession	13	400 00
Deer—closed season—killing	4	160 00
Birds (non-game)—possession	2	75 00
Doe—closed season—killing	2	125 00
Pigeons—closed season—killing or possession	3	50 00
Quail—closed season—possession or killing	3	10 00
Geese (wild)—closed season—possession	3	25 00
Bear—closed season—killing	1	
Beaver hide—possession	1	25 00
Doves—closed season—killing or possession	5	175 00
Brush rabbits—closed season—killing	2	75 00
Cottontail—closed season—possession or killing	2	60 00
Spike buck—killing	1	100 00
Cub bear—taking	1	10 00
Discharging oil in San Francisco Bay	1	200 00
Making false statement on application	1	25 00
Failure to produce license on demand	1	25 00
Total game violations	55	$1,620 00
Fish.		
Angling without license	23	$470 00
Striped bass—undersized, offering for sale underweight, shipping undersized, possession or excess limit	22	580 00
Black bass—closed season—possession, undersized or spearing	11	175 00
Crabs—undersized, possession	5	100 00
Crab meat—detached from shell	1	100 00
Abalones—undersized, possession—closed season	38	1,535 00
Abalones—failure to bring to shore attached to shell	1	25 00
Clams—excess limit—undersized—possession	12	290 00
Trout—excess limit—selling—taking in closed season	8	240 00
Catfish—selling undersized—retaining undersized in live cars	3	60 00
Perch—closed season—possession	2	
Sturgeon—possession	1	20 00
Lobsters—undersized, possession—closed season	3	65 00
Halibut—undersized—selling	1	25 00
Fishing within 250 feet of fishway	7	175 00
Fishing for profit without license	9	100 00
Fishing for profit excess limit	1	25 00
Fish trap, using	1	
Trawl net, using in District 9	2	200 00
Dragging inside three-mile limit	1	100 00
Illegal net in restricted district	4	300 00
Saturday-Sunday fishing	2	40 00
Taking fish without hook or line	1	25 00
Total fish violations	159	$4 650 00
Grand total fish and game violations	208	$6,310 00

CALIFORNIA FRESH FISHERY PRODUCTS FOR MONTHS OF APRIL, MAY AND JUNE, 1921.

Compiled by Fish and Game Commission, Department of Commercial Fisheries.

Species of fish	Del Norte, Humboldt	Mendocino, Sonoma, Lake	Marin	Solano, Yolo	Sacramento, San Joaquin	Tehama, Colusa, Glenn, Butte	Contra Costa, Alameda	San Francisco, Alameda	Santa Cruz	Monterey	San Luis Obispo, Santa Barbara, Ventura	Los Angeles	Orange	San Diego	Imperial	Total	Mexican, brought into California
Albacore												2,177		667		2,844	
Anchovies								57,420		489,192		6,068		228,764		781,444	
Barracuda											13,815	2,054,474	14,603	650,292		2,733,184	35,355
Bluefish									494	10,678						11,172	
Boccaccio		125						11,942	11,904	193,168						217,139	
Bonito											45	6,323	27	6,718		13,113	555
Carp			67	2,647			9,070	5,904								17,688	
Catfish		3,353		3,754	699		10,005									17,811	
Chilipepper					18,018				883							18,901	
Cultus Cod	3,209	1,293						17,301	10,267	22,482						54,552	
Dolphin																	
Eels																	
Flounders	41		56	183			4,519	70,258	10,925	434	996	1,136				88,578	
Grayfish							507	1,500				2,450	250	183,140		187,847	
Greenfish																	
Hake								22,838	488							23,326	
Halibut	11,940	2,132						3,792	538	2,990	108,926	541,365	58,071	179,818		909,572	142,660
Hardhead				32												32	
Herring			4,925								269					5,194	
Kingfish								1,245	14,995	36,057	55	81,258	534	1,031		135,175	425
Mackerel									987	20,117	2,630	449,266	8,507	130,556		612,043	1,953
Marlin																	
Mullet												301		8,574		8,875	
Perch	1,738		8,495				311	8,876	2,024	9,521	18	25,395	679	337		57,394	
Pike				736	123	27	907									1,793	
Pompano									17	138	108	4,549	52	110		4,974	
Rock Bass												51,482	13,193	58,435		123,110	1,795
Rockfish	13,628	2 348	110					55,852	21,312	61,576	17,484	198,274	5,066	112,023		487,673	12,987
Sablefish								62,196	280,213	3,541						445,950	
Salmon	42,085	995,562	407	187,537	221 868	108,439	289,925	127,618	371.753	680.084						3,025,278	
Sandabs								197,814	13,000	2 124		2,389	13			215,340	
Sardines			138					750	100	1,013,484		6,031,195		155,030		7,200,697	
Sculpin												18,635		4,836		23,471	
Sea Bass—Black											378	9,336	553	11,733		22,000	1,707
Sea Bass—White									22	23	3,427	974,202	1,870	125,739		1,105,283	10,449
Sea Trout												29	833	700		1,562	
Shad				2,109	470		6,157	16,496								25,232	
Shad—Buck				37,153	23,331		152,306									212,790	
Shad—Roe				71,094	25,919		443,125									540,138	
Sheepshead											89	1,631	67	7,496		9,283	

Skates					43,146			8,765				260	358			52,529		
Skipjack																		
Smelt	19,998		3,005				5,156	38,479	11,856	8,689	27,806	28,731	174	3,007		146,901	240	
Sole	76							761,762	111,028	22,275	8,251	16,926	596			920,914		
Splittail				46			140									186		
Striped Bass			1,332	30,028		48	76,179	48,961						6,795		156,548		
Stingaree																6,795		
Suckers																		
Surf Fish																		
Swordfish												332				332		
Tomcod								6,490								6,490		
Trout—Farm																		
Trout—Steelhead																		
Tuna												72,157		54,201		126,358	42,991	
Tuna—Bluefin												87,128				87,128	59,835	
Tuna—Yellowfin												4,205				4,205	5,558	
Turbot			73													73		
Whitebait			708					308								1,016		
Whitefish											120	1,818		752		2,720		
Yellowtail												241,918	34	83,484		325,436	7,769	
Miscellaneous		1,390					176	5,744	6,109	74,821	3,249	11,725	816			104,030		
Croakers												10,223				10,223		
Total fish	92,715	1,006,208	19,316	335,319	333,574	108,514	998,483	1,532,311	968,895	2,651,424	187,666	10,937,388	106,296	2,014,238		21,292,342	324,279	
Crustaceans:																		
Crabs (doz.)	1,388	86	27					5,277	15	1						6,794		
Ecrevisse (doz.)																		
Shrimps								214,232		1,006		25				215,263		
Spiny Lobsters																	318,456	
Mollusks:																		
Abalones	3,308		405							409,342	8,212					421,357		
Clams—Cockle	320	415	1,997									83				2,815		
Clams—Mixed	3,070		13,762								46					16,878		
Clams—Pismo											73,637					73,637		
Clams—Softshell	154	4,371	195					13,771								18,421		
Cuttlefish			23					1,899	1,785	9,632		19				13,358		
Limpets																		
Mussels										60						60		
Oysters—Eastern (No.)			621,010							985						621,995		
Oysters—Native			6,540													6,540		
Snails																		
Squid										116,398		26,759		86,482		229,639		
Miscellaneous:																		
Frogs (doz.)																5		
Terrapins (doz.)		5															1,690	
Turtles											735					735		
Scallops																		

All amounts shown in pounds unless otherwise specified.

SEIZURES.

Fish and Game and Illegally Used Fishing Apparatus.

Game.

Ducks	6
Deer meat	158 lbs.
Blue cranes 11	90 lbs.
Rabbits	13
Pigeons	7
Geese (wild)	5
Beaver hides	2
Doves	6
Quail	3

Fish.

Striped bass	1420 lbs.
Striped bass	12
Black bass	4 lbs.
Black bass	4
Clams (Pismo)	1871
Clams (cockle)	28¼ lbs.
Lobsters	19
Lobsters	91½ lbs.
Sole	18 lbs.
Crabs	295
Crab meat	8 lbs.
Abalones	333
Abalones (black)	15
Trout	413
Trout	2½ lbs.
Perch	4 lbs.
Catfish	35 lbs.
Barracuda	2720 lbs.
Halibut	365 lbs.
Sturgeon	18 lbs.
Shad	1
Carp	1
Illegal nets	3

FISH AND GAME COMMISSION.

Statement of Expenditures for the Period from July 1, 1920, to June 30, 1921.

Administration:		
Commissioners	$1,115 49	
Executive offices	26,443 43	
Printing	8,073 62	
Research and publicity	6,073 62	
Accident and death claims	1,754 69	
		$43,460 85
Commercial fish culture and conservation:		
Superintendence	$15,731 18	
Inspection and patrol	31,488 15	
Research	31,257 88	
Statistics	10,269 64	
Market fishermen's license commissions	535 50	
Propagation and distribution of salmon	26,164 92	
		115,447 27
Sporting fish culture and conservation:		
Superintendence	$15,058 43	
Printing	299 54	
Prosecutions and allowances	496 15	
Angling license commissions	16 879 50	
Fish exhibits	4,323 19	
General patrol (pro rata share)—		
San Francisco District (40 per cent)	39,296 85	
Los Angeles District (40 per cent)	16 981 60	
Sacramento District (40 per cent)	28,774 32	
Propagation and distribution of trout	150,405 57	
		272,515 15
Game conservation:		
Printing	$461 13	
Prosecutions and allowances	1,057 45	
Hunting license commissions	24,605 60	
Mountain lion hunting (and bounties)	8,489 98	
General patrol (pro rata share)—		
San Francisco District (60 per cent)	58,713 22	
Los Angeles District (60 per cent)	25,370 37	
Sacramento District (60 per cent)	43,158 88	
		161,856 63
Tahoe camping ground		684 04
Total		$593,963 94

INDEX VOLUME 7.

A

Abalone, 68, 71, 81, 121, 128, 131, 168, 174, 213, 262, 273; a distributional note on Haliotis, 254-255.
  Alaskan white, 254.
  Northern green, 254.
  Red, 174.
Accipiter velox, op., 134, 135.
Accident, hunting, 117, 263.
Acclimatization, 74, 76.
Act, 76, 78.
  Migratory Bird Treaty, *see* Migratory.
  Districting, 86.
  Lacey, 47.
Administration, 69, 73, 81, 83, 132.
Agar-agar, 177.
Airplane, duck hunting from, 158.
Albacore, 39, 59, 70, 106, 108, 109, 110, 124, 130, 176, 219, 220, 221, 222, 272; the albacore season, 268-269.
"Albacore," launch, 64.
Alexander, Commissioner, 65.
American Agar Company, 176.
American Association for Advancement of Science, 177.
American Game Protective Association, 66, 113.
Anatomy, 114.
Anchovy, 23, 33, 70, 110, 111, 130, 211, 212, 213, 231, 232, 269, 272.
Angler, 42, 46, 49, 84, 122; and sportsmen's organizations, 44.
Animal, 62, 79, 100, 103, 108, 110, 111, 116, 119, 127.
  Aquatic, 118.
  Domestic, 99.
  Fur-bearing, 46, 65, 67, 118, 119, 120, 127, 128.
  Game, 67.
  Predatory, 99, 118.
Antelope, show increase, 128.
  Prong-horn, 128.
Antilocapra americana, 128.
Aquarium, 43, 126.
  Car, 74, 75.
Aquila chrysaetos, 139.
Argabrite, J. R., 80.
Arrest, 44, 48, 68, 85, 112, 115.
Association, American Game Protective, 66, 113.
  Lindsay Fish and Game Protective, 113.
  National Canners', 203, 246, 248.
  Northern California Hotel Men's, 86.
  Yuba County Fish and Game, 113.
Auklet, 136.
Austin, Geo. P., 184.
Author, Finding list of, *see* Finding List.
Automobile, 52, 103; confiscated in Wisconsin, 66.
  Truck, 122.
Awa, 75.
Ayu, 76, 121.

B

Babcock, John P., 83.
Bacon, J. S., 265-266.
Badger, 182.
Bag limit, 67, 83, 84, 104, 105, 158, 267.
Bait, 25, 32, 33, 35, 37, 111, 182, 196, 220.
Bamboo, 25.
Banding, bird, 167.
Barracuda, 68, 70, 130, 176, 221, 272.
Bass, Black, 70, 74, 75, 130, 272; fishing in Lake County, 161.
  Rock, 70, 75, 130, 270, 272.
  Sea, 70, 130, 221, 272.
  Striped, 68, 71, 76, 84, 128, 131, 175, 273.
  White, 70, 130, 272.
Bear, 68.
  Black, 65.
Beard, Harry R., California sardine food products and their preparation, 238-247; a selected bibliography of chemical literature, 256-260.
Beaver, wire halts, 267.
  Pelt, 116.
Benton, Assemblyman, 176.
Bermingham, Jr., Hon. E. L., 84.
Berry, S. Stillman, a distributional note on Haliotis, 254-255.
Bibliography, 147; of chemical literature, fish industry, 256–260.
Biennial Report, 87, 88-89; 1870-1871, 77; 1886-1888, 78; 1888-1890, 79; 1895-1896, 79; 1910, 80; 1914, 85; 1918-1920, 44, 112, 116.
Bill, 121, 124.
  Flint-Cary, 85, 86.
Biologist, 166.
Biology, 59, 106, 110.
Bird, 47, 61, 64, 79, 81, 111, 114, 115, 118, 128, 151, 231, 252, 264, 265.
  Black, 136.
  Banding, 167.
  Game, 67, 79, 80, 83, 266.
  Upland, 47.
  Nongame, 81.
  Sea, 60.
  Song, 160, 262.
  Water, 142.
Bivalve, 112.
Blood, Roy H., a trapper's experiences, 184.
Bluefish, 70, 130, 272.
Blue Jay, 136; hunt in San Benito County, 115.
Boar, hunting the wild, in Central France, 102.
Boat, 23, 24, 25, 26, 29, 30, 36, 37, 46, 56, 219.
  Patrol, 81, 163.
  Power, 24, 56.
  Sail, 24, 56.

Bobcat, 101, 118.
Boccaccio, 70, 130, 270, 272.
Bonito, 70, 130, 272.
Book, a noteworthy, 270.
Bosqui, E. L., 84.
Bounty, 183.
Bowline, 32, 36.
Britton, Deputy, 121.
Brown, Wm. S., the porcupine as food, 127.
Bruce, Jay C., 48, 100, 101, 168; three mountain lion kittens captured, 62-63; mountain lion swims river, 180-181.
Bryant, H. C., 62, 80, 81, 113, 127, 263; a brief history of the California Fish and Game Commission, 73-86; publications of the California Fish and Game Commission, 1870-1920, 87-98; tree squirrels infested with scabies, 128; California hawks, how to identify them, 133-147.
Buck, *see* Deer.
Buckingham, Hon. R. H., 84.
Bulletin, 87.
  Fish, 87, 90-91, 179; new, 112; No. 4, the edible clams, mussels and scallops of California, 112; No. 5, a key to the families of marine fishes of the West Coast, 112.
  Fisheries Service, 116.
  Game, 87, 91, 94.
  Miscellaneous, 87, 91-92.
  Teachers', 87, 91.
Burke, Deputy, 168.
Buteo, 135.
  borealis, 136.
By-product, 204.
Buzzard, Turkey, 143.

C

California Acclimatization Society, 74.
CALIFORNIA FISH AND GAME, 42, 59, 60, 61, 81, 87, 92, 106, 108, 122, 151, 169, 176, 177, 184, 193, 194, 266; reprint and separate, 87, 92-94.
California-Oregon Power Company, 123.
California State Board of Health, 120.
California State Fisheries Laboratory, Contribution No. 22, 38-41; No. 23, 59-61; No. 23, 103-106; No. 24, 106-110; No. 25, 177; No. 26, 177; No. 27, 110-111, 177; No. 28, 177-180; No. 29, 150-153; No. 30, 192-194; No. 31, 195-206; No. 32, 207-218; No. 33, 219-237; No. 34, 268-270.
Campaign, educational and publicity, 44, 81, 84, 112.
Camping, 67.
Camp, *see* Tahoe Camp Ground; sanitation, 119-120; municipal, increase in national forest parks, 163.
Can, 119, 120.
  Half-pound oval, 39.
  Quarter oil, 39; or half-pound ovals, 106-110.
  Pound oval, 40.
Cannery, 10, 42, 59, 60, 61, 106, 112, 124, 176, 195, 230, 236, 238, 240; inspection in fish, 248-249; sardine, 48.
Cannerymen, 59, 61.
Canning, 77, 106, 125.
  Industry, 38.
Canvasback, 46.
Caribou, 47.
Carp, 70, 76, 84, 130, 141, 272.
Carpenter, Deputy, 121, 268.
Carter, Hon. Jesse W., 154.
Case, 168.
Cat, 114, 128, 184.
  Domestic, 63, 67.
  Wild, 118.
Catfish, 70, 74, 130, 272.
Cetorhinus maximus, 178.
Chamber of Commerce, 113, 122.
Chicken, Prairie, 66.
Chilipepper, 70, 130, 270, 272.
Chipmunk, 136.
Chucklehead, 270.
Church, S. C., curlew numerous, 181.
Civil service, 81.
Circus hudsonius, 141.
Clam, 81, 112, 124, 174, 273.
  Cockle, 68, 71, 128, 131, 273.
  Pismo, 59, 68, 71, 128, 131, 174, 273; the abundance of young, 103-106, 177.
  Soft shell, 46, 71, 131, 273.
Clark, Deputy M. S., 45, 168.
Clark, Frances N., 269.
Clarke, Frank C., 81.
Clayton, Henry D., Judge, 162.
Club, 44, 79, 113, 161.
  Alturas Sportsman, 113.
  Angling, 127.
  Caspar Rod and Gun, 113.
  El Dorado Rod and Gun, 113.
  Fresno Sportsman, 113.
  Grass Valley Sportsman, 113.
  Lake County Fish and Game Protective, 161.
  Sierra Rod and Gun, 113.
  Sportsmen's, in New York, 185.
Clupea harengus, 193.
  sprattus, 193.
Cobb, John N., 54.
Cod, 108, 213.
  Black, 111.
  Cultus, 70, 130, 272.
  Grey, 110.
  Red, 110, 111.
  Rock, 219, 270.
Commercial fishery department, 44, 46, 48, 53, 79, 110.
Commercial fishery notes, 54-58, 124-127.
Commissioner, 60, 77, 83; list of Fish and Game, 1870-1920, 84.
  of Fisheries, Province of British Columbia, 7.
  of Fisheries, United States, 7, 12.
  Alexander, 65.
  Board of Fish, 74, 78.
  Louisiana State Conservation, 65.
Commission, *see* Fish and Game Commission.
Condor, 143, 146.
Conference, the National Game, 113-114.
Confiscation, 65.
Congress, 47.
  Connell, Hon. M. J., 44, 84.

Conservation, 43, 44, 46, 55, 58, 69, 73, 81, 113, 117, 132, 185, 268; the system of, in Pennsylvania, 66; reader for California schools, 117-118; in other states, 65-67, 185; and the scientific collector, 160; of fisheries, resolution on the, 162; game, 82, 84, 114, 132; interest in fish and game, in Utah, 185; wild life, 81; President Harding in sympathy with, 118-119.
CONSERVATIONIST, THE, 65, 117, 163, 185.
"Conservation through education," 81, 87.
Cormorant, 252.
Court, Superior, 57, 85.
Supreme, of the United States, 67, 83, 85.
Cow-horn, 102.
Coyote, 118, 121, 182, 183.
Crab, Edible, 68, 71, 81, 121, 128, 131, 273.
Crail, Judge C. S., 176.
Croaker, 176, 273.
Spot-fin, 176.
Yellow-fin, 176.
Crustacea, 11, 71, 111, 124, 131, 273.
Curlew, Hudsonian, 181.
Jack, 181.
Cuttlefish, 71, 131, 273.

D

Dado, S. H., 261; fisheries, 1920, 124-125.
Dearborn, Ned, 118, 119.
Deer, 48, 65, 68, 78, 81, 83, 85, 86, 99, 100, 101, 112, 117, 118, 120, 128, 182, 183, 184, 262, 263, 267; two, at one shot, 47; albino, seen in Stanislaus forest, 182.
Dendrocygna bicolor, 64.
Deputy, 79, 83.
Dibble, Hon. A. B., 84.
Didelphis virginiana, 62, 184.
Disease, 128.
Distribution, 43, 84, 106, 110, 114, 119, 122, 123, 124; trout and salmon, 49.
Car, 49.
District, 125, 128, 175.
Fish and game, 175.
Dixon, J., 181.
Doe, *see* Deer.
Dog, 63, 67, 100, 101, 102, 114, 128, 181, 183.
Dogfish, 111.
Dolphin, 269, 272.
Dolter, Carl, 254.
Doney, A. E., 51.
Dove, 68, 79, 83, 85, 128, 136, 137, 266; wrong season on, 47; introduced, thrives in Los Angeles, 180.
Chinese Spotted, 180.
Duck, 48, 66, 68, 79, 83, 120, 121, 128, 136, 160, 166, 264, 266; move to new feeding grounds, 46.
Black, 167.
Canvasback, 46.
Fulvous tree, shot near Colusa, 64.
Lesser Scaup, 46.
Mallard, 167.
Pintail, 115.
Ring-necked, 167.
Teal, Blue-winged, 167.
Wood, help save the, 46.
Dynamite, 85.

E

Eagle, 135, 264.
Bald, 139, 143, 146.
Black, 182.
Golden, 139, 143, 144, 146.
Ecrevisse, 273.
Eddy, Robert E., 113.
EDITORIALS:
A salmon number, 42; Klamath River salmon threatened with extermination, 42; in memoriam, Ralph W. Requa, 43; the 1920 biennial report, 44; sportsmen's and anglers' organizations, 44; proposed federal hunting license, 44; golden trout, 44; why? 45; nets confiscated, 45; bottom drops out of the fur market, 45-46; Commission complimented by bureau officials, 46; hunting and angling licenses, 46; ducks move to new feeding grounds, 46; help save the wood duck, 46; game laws for 1920, 46-47; wrong season on doves, 47; two deer at one shot, 47; people and the law, 112; the 1918-1920 biennial report, 112; new fish bulletins, 112; fish-cultural methods upheld, 113; in memoriam, Frank Shook, 113; the national game conference, 113-114; the steelhead, a distinct species, 114; salmon destroyed on spawning beds, 114; blue jay hunt in San Benito County, 115; more fines for hunting out of season, 115; more and better fur, 116; rainbow trout in Hawaii, 116; a decline in the consumption of fish, 116-117; buck law decreases hunting accidents in New York, 117; a conservation reader for California public schools, 117-118; President Harding in sympathy with wild life conservation, 118; fur-bearers protected in Trinity Refuge, 118; the fur supply and its maintenance, 118-119; camp sanitation, 119-120; New York's annual game dividend, 120; a hawk number, 157; some important changes in the laws affecting game, 157; summer resort work to be continued, 158; are bag limits too large, 158; duck hunting from an airplane, 158-159; salmon depletion in British Columbia, 159-160; conservation and the scientific collector, 160; power project hearing, 161; good black bass fishing in Lake County, 161; Lake County sportsmen organize, 161-162; Judge Clayton and the Migratory Bird Law, 162; resolution on the conservation of fish-

EDITORIALS—Continued.
eries, 162; chinook salmon in Lake Ontario, 162-163; the Fish and Game Commission patrol service, 163; municipal camps increase in national forest parks, 163-164; establish quarantine on foxes imported for breeding, 164; the silver fox ranch at Lake Tahoe, 164-166; wild fowl need protection and feeding grounds, 166; bird banding, 167; a sardine number, 261; comparison of sardine catch, 262; summer resort educational work, 1921, 262; state fair exhibit, 1921, 262; hunting accidents, 263; public shooting grounds, 263; unnatural natural history, 264; migratory birds in Latin America, 265; rainbow trout acclimatized in Australia, 265; Australia seeks information on fishways, 266; new bird law prohibits guides from making kill, 266-267; a sea elephant near San Clemente, 267.
Edwards, Chas. L., 81.
Edwards, Miss Helen M., 177, 178, 269.
Eel, 130, 272.
Salt water, 74, 75.
Silver, 75.
Egg, 50, 53, 74, 76, 107, 108, 110, 116, 123, 126, 172.
Ayu, 121.
Collecting station, 170.
Dove, 47.
Loch Leven, 124.
Quail, 115.
Salmon, 8, 12, 14, 15, 16, 17, 18, 21, 51, 52, 58, 124, 161; how many does a salmon lay?, 63-64.
Sardine, 107, 110.
Steelhead, 124.
Trout, 122, 169, 172; rainbow, 172; steelhead, 172.
White fish, 75.
Electro-Metals Company, 42.
Emeric, Hon. H. F., 84.
Enemy, 108.
Eucalyptus, 25.
Eulachon, 7.
Exhibit, State Fair, of fisheries, 177; State Fair, 1921, 262-263.
Expenditure, 44, 69, 80, 132, 187.

F

Facts of current interest, 48, 121, 168.
Fairbanks, H. W., 117.
Falcon, 135, 137.
Peregrine, 145.
Prairie, 145.
Falco sparverious, 137.
Farmer, 66, 118, 119.
Bulletin, 47.
Farnum, F. A., 117.
Farwell, Hon. J. D., 74, 84.
Fawn, 139, 183.
Federal Power Commission, 42.
Fertilizer, 110; shall we use food fish for, 124; stock food and oil from sardine offal, 207-218.
Field, G. R., 10.
FIELD AND STREAM, 65.
Film, wild life, 44.
Fin, 125, 126.
Adipose, 126.
Caudal, 9, 11.
Dorsal, 9, 11, 126.
Finding list, of authors, 97-98.
Subjects, 94-97.
Fine, 48, 65, 66, 86, 112; more fines for hunting out of season, 115, 168.
Fin-ray, dorsal, 126.
FINS, FEATHERS AND FUR, 185.
Fish, 3, 4, 6, 7, 11, 12, 14, 17, 18, 22, 23, 24, 25, 29, 31, 32, 33, 35, 36, 37, 38, 39, 42, 44, 48, 49, 50, 53, 57, 58, 61, 64, 66, 67, 74, 79, 81, 83, 84, 85, 87, 106, 107, 108, 109, 110, 112, 113, 114, 116, 121, 122, 123, 124, 125, 128, 129, 139, 170, 184, 248, 249, 252; some considerations concerning the salting of, 54-55; a decline in the consumption of, 116-117; a new species of, from Santa Catalina Island, 126; rare, taken at San Pedro, 270.
Black, near Santa Catalina Island, 64.
Cutlass, 179.
District, 49.
Food, 42, 50, 52, 74, 110; shall we use food fish for fertilizer?, 124.
Game, 74, 161.
Industry, selected biblography of chemical literature pertaining to, 256-260.
Ladder, 42, 77, 123.
Law, 44, 83, 112; violation of, 48, 68.
Marine, 79, 126.
Marked, 36, 37.
Meal, 124, 207, 208, 211, 216, 236, 240.
Migratory, 114.
Miscellaneous, 273.
Oil, 55, 207, 208.
Patrol, 84.
Planting, 43, 44, 122.
Predaceous, 53.
Propagation, 83.
Rack, 50, 52, 53, 58.
Rag, 178.
Reduction, 174.
Screen, 43, 52.
Surf, 272.
Warden, 7, 66.
White, 75, 76.
Fish and Game Commission, California, 1, 9, 10, 22, 42, 43, 44, 45, 49, 59, 62, 63, 99, 100, 105, 112, 113, 114, 116, 121, 122, 124, 125, 126, 151, 163, 174, 175, 177, 178, 194, 204, 219, 235, 261, 262, 263; complimented by bureau officials, 46; a brief history of the, 73-86; publications of the, 1870-1920, 87-98.
Hawaii, 116.
Patrol service, 163.
Pennsylvania State, 65.
Vermont, 65.
Virginia, 114.
Fishcultural, methods upheld, 113.
Fishculture, 43, 69, 74, 114, 132.
Department of, 83, 87, 126.
Fishculturist, 116, 124.
Fisher, A. K., 142.

Fisherman, 7, 10, 23, 24, 25, 29, 31, 32, 33, 34, 35, 36, 37, 41, 44, 48, 57, 61, 75, 78, 86, 111, 117, 125, 159, 176, 183, 196, 220, 223, 248, 269.
Chinese shrimp, 77, 79.
Commercial, 52, 53, 58, 84.
Market, 168.
Fishery, 38, 39, 41, 46, 58, 59, 60, 81, 106, 109, 112, 125, 151, 195, 219, 252, 261, 270; 1920, 124-125.
Commercial, department of, 46, 112, 126, 150, 262.
Commercial legislation, 174.
Halibut, 111.
Industry, 110.
Laboratory, 55; notes from San Pedro, 176; progress of the new, 60; State, 48, 81, 126.
Notes from San Pedro, 176.
Pacific, Society meeting, 177.
Products, California fresh, 70-71, 130-131, 272-273.
Resolution on the conservation of, 162.
Salmon, 4, 42, 111, 205, 206.
Sardine, 39, 40, 59, 106, 110.
Shrimp, 77.
Statistics, 112.
Fishing, 4, 7, 22, 23, 24, 25, 31, 37, 39, 49, 52, 53, 58, 59, 67, 105, 109, 113, 117, 122, 124, 125, 231, 237.
Bass, in Lake County, 161.
Commercial, 84, 151, 163.
Industry, 42, 54, 55, 57, 112, 116.
Market, 84.
Fishway, 42, 51, 77, 123; Australia seeks information on, 266.
Fly, 11.
Flounder, 70, 130, 272.
Follett, Charles, wrong season on doves, 47.
Food, 7, 8, 10, 23, 42, 54, 58, 61, 111, 114, 117, 125; porcupine as food, 127.
Poultry, 124.
Sea, 121.
Forest, National, 47, 163.
California, 163.
El Dorado, 128.
Fowler, District Ranger, 182.
Fowler, F. H., 161.
Fox, 182; ranch at Lake Tahoe, 164-166; quarantine on foxes imported for breeding, 164.
Grey, 182.
Freeborn, Stanley B., 125.
Freer, Ranger, 182.
Frog, 142, 273.
Fry, 2, 49, 50, 51, 52, 53, 123, 124, 125, 126, 169.
Eastern brook, 113.
Salmon, 123, 124, 126.
Trout, 112, 122, 169, 172.
Fungus, 50, 121.
Funston Brothers and Company, 45.
Fur, 45, 46, 116, 118, 119, 182; bottom drops out of market, 45-46; more and better, 116; supply and its maintenance, 118-119; Quebec licenses, 65.
Dealer, 45, 46, 116.
Market, 45.
Trade, 65, 118.
Fur-bearer, 116; protected in Trinity Refuge, 118.
Fur-bearing animals of New York State, annual dividend from, 185.
Fulmar, 234.

G

Game, 44, 45, 65, 66, 74, 78, 79, 80, 81, 83, 85, 87, 99, 115, 121, 122, 128, 129, 185, 264; value of Pennsylvania's annual kill of, 65; New York's annual game dividend, 120.
Animal, 67.
Bag, 102.
Big, 47, 117.
Bird, 67, 79, 80, 83.
Bulletin, *see* Bulletin.
Conservation, 69, 81, 82, 84, 114.
District, 49.
Farm, 80.
State, 79, 80, 81.
Law, 44, 48, 66, 79, 81, 83, 112; for 1920, 46-47; violation of, 48, 68, 129.
Legislation, 47.
Mammal, 80.
Preserve, 66.
Refuge, 44, 65, 66, 67, 82, 100, 101, 113; No. 1-D, 118.
Warden, 66, 115.
Federal, 44, 115.
Garbage, 119, 120.
Gear, 109, 162, 221, 223, 228; used for salmon trolling in California in 1920, 22-38.
Gelidium sp., 176.
Gerber, Hon. W. E., 84.
Getchell, Florence, 43.
Gilbert, C. H., 7, 81, 159, 269.
Gill, 37, 110.
Gilmore, Charles L., 81.
Goose, 79, 264.
Gopher, 133, 138.
Gould, Hon. C. B., 84.
Gray, Deputy Euell, 128.
Gray, Hon. Lendal N., 84.
Gray, Senator, 175.
Grayfish, 70, 130, 272.
Greenfish, 272.
Green, George A., 113.
Greyling, 76.
Griffin, Judge Ray, 168.
Grouper, Salmon, 270.
Grouse, Ruffed, 47, 262.
Groves, Deputy, 168.
Grunion, 179.
Gull, 232; the habits of sea, 60-61; a further note on the Monterey, 61.
Glaucous-winged, 61.
Herring, 61.
Western, 61.
Gun, 66, 102.

H

Haight, H. H., 74.
Hake, 70, 130, 272.
Halbrook, L. V., 159.
Haliaeetus leucocephalus, 140.
Halibut, 39, 68, 70, 110, 128, 130, 176, 219, 272.
Fishery, *see* Fishery.
Food, 110.
Halfhill Packing Corp., 176.

Haliotis, a distributional note on, 254, 255.
cracherodii, 255.
holzneri, 255.
imperforata, 255.
giyantea, 254.
kamtschatkana, 254, 255.
walallensis, 254.
Hardhead, 70, 130, 272.
Harding, President Warren G., 118.
Hansen, A. C., fulvous tree-duck shot near Colusa, 64.
Harrier, 135, 141.
Harrington, Deputy, 45.
Harvey, Hon. J. Downey, 78, 84.
Hatchery, 8, 52, 53, 74, 77, 80, 83, 114, 122, 123, 124, 125, 126, 262.
Almanor, 124.
Baird, 74.
Bear Lake, 172.
Blairsden, 122.
Bogus Creek, 170.
Brookdale, 123, 124, 169, 170, 171.
Clear Creek, 124, 172.
Domingo Springs, 124, 171, 172.
Fall Creek, 50, 123, 169.
Feather River, 172.
Fort Seward, 52, 53, 124, 169, 170, 171.
Hat Creek, 77.
Hornbrook, 170.
Kaweah, 124, 169, 171, 172.
Klamathon, 42, 50, 123, 169.
Mount Shasta, 2, 3, 5, 49, 78, 122, 123, 126, 169, 170, 171, 172.
Mount Tallac, 122, 170.
Mount Whitney, 44, 124, 169, 170, 171, 172.
North Creek, 172.
Rae Lakes, 170.
Scott Creek ,171.
Sisson, 43, 76.
Snow Mountain, 171.
Tahoe, 82, 112, 122, 170, 171.
Ukiah, 123, 124, 169, 170, 171, 172.
Warner Creek, 172.
Wawona, 124, 169, 171, 172.
Willow Creek, 51, 52.
Hatchery notes, 49-53, 122-124, 169-173.
Hawk, California, how to identify them, 133-149; number, 157.
Bullet, 135, 144.
"Chicken," 135, 144.
Cooper, 144, 146.
Darter, Blue, 144.
Duck, 136, 137, 138, 145, 146.
Fish, 141, 145.
Goshawk, 144, 146.
Grouse, 144.
Hen, 137, 143.
"Killy," 140, 145.
Marsh, 135, 141, 142, 144, 146.
Merlin, 145.
Mouse, 144.
Pigeon, 141, 145, 146.
Prairie Falcon, 145, 146.
Quail, 144.
Red-bellied, 138, 144, 146.
Red-tailed, 136, 138, 143, 146.
River, 144.
Rough-leg, Ferruginous, 138, 143, 146.
Sharp-shinned, 135, 140, 144, 145, 146.
Sparrow, 137, 140, 145, 146.
"Squirrel," 138, 143.
Swainson, 138, 144, 146.
Heacock, R. B., 55.
Heath, Harold, 81.
Hendrickson, Norman, inspection in the southern California fish canneries, 248-249.
Hearing, power project, 101.
Herring, 38, 39, 106, 107, 108, 110, 111, 130, 193, 195, 199, 272.
History, unnatural, natural, 264-265.
Higgins, Elmer, 260; methods of sardine fishing in southern California, 219-237; rare fish taken at San Pedro, 270.
Holland, Ray P., 66.
Holmes, Harland B., 59, 60, 193, 269; methods of sardine fishing in southern California, 219-237.
Hook, 8, 11, 27, 28, 29, 31, 33, 34, 36, 37, 44, 177; barbless fish, 127.
Bait, 35.
Gaff, 37.
Kirby, 35.
Snap, 26.
Hook-leader, 35, 36.
Horn, 117, 183, 184.
Horn-pout, 75.
Hubbs, Carl L., 126.
Hunt, E. W., 83.
Hunter, 44, 46, 48, 62, 67, 79, 83, 86, 99, 100, 101, 102, 115, 117, 167, 183, 263.
Hunter, J. S., 113; the control of the mountain lion in California, 99-101.
Hunting, 67, 102, 266; more fines for hunting out of season, 115; buck law decreases accidents in New York, 117; the wild boar in central France, 102.
License, 66, 120; and angling, 46; law, 79, 85.
Hypomesus, 269.

I

Ichthyologist, 84, 114.
Icosteus aenigmaticus, 179.
acrotus willoughbyi, 179.
ILLINOIS SPORTSMAN, 45.
Illinois Sportsmen's League, the platform adopted by the, 66-67.
Insect, 111.
Inspection, 65.
International Association, of Fish, Game and Conservation Commissioners, 44.

J

Jay, Blue, 136.
Jones, Justice, 121.
Jordan, Hon. David Starr, 84.
Josselyn, Charles, 84.
Jotter, E. V., fur-bearers protected in Trinity Refuge, 118.

K

Keller, Hon. Henry W., 84.
Kelly, H. L., 116.
Kelp, 174, 263, 268, 269.
Kendall, W. C., 114.
Key, 112, 134, 142, 143, 146.
Killdeer, 141.
Kingfish, 70, 130, 272.
Kitten, Lion, 99.
Kite, White-tailed, 141, 144, 146.

L

Laboratory; preservation, 238, 247, 256; state fisheries, 150, 261, library for the new, 178; the new, 268; staff, 269.
Ladder, *see* Fish.
Lampara, *see* Net.
Larva, 110.
Law, 42, 67, 77, 79, 83, 104, 105, 107, 112, 113, 115, 118, 124, 128; prohibits guides from making kill, 266-267.
  Angler license, 85.
  Buck, 47; decreases hunting accidents in New York, 117.
  Federal, 46, 86, 115.
  Fish, 112, 168.
  Fish and game, 44, 48, 66, 83, 87, 89-90, 94.
  Fishway, 152.
  Game, 79, 81, 112, 266; for 1920, 46-47; important changes in, 157.
  Hunting license, 79, 85.
  Postal, 86.
Lead, 23, 25, 26, 27, 28, 29, 30, 31, 32, 38.
Leader, 29, 31, 32, 35, 36, 38.
Leahy, Deputy Bert, 45.
Lecture, 113.
Legislation, 47, 76, 87; commercial, 174; protective, 79, 112.
Lencioni, Deputy, 168.
Lewis, William, 164.
Libby, Gretchen, 81.
Libby, R. D., 184.
Library, for new laboratory, 178; the, 269.
License, 47, 65.
  Angler's, 85.
  Angling and hunting, 46.
  Federal, 113; proposed federal hunting, 44.
  Fishing, 66, 79, 268; and angling, 46.
  Hunting, 66, 120, 268.
  Sale, 44.
  State, 44, 114.
Life history, 4, 81, 103, 112.
  Notes, 62-64, 127.
Limit, 47, 114, 121.
  Bag, *see* Bag.
  Size, 104.
Limpit, 71, 273.
Line, 23, 24, 25, 26, 27, 28, 29, 31, 33, 36, 37, 38, 44.
  Bass, 36.
  Chinese set, 77.
Lion, 183; mountain, 48, 85, 118, 168, 264; three mountain lion kittens captured, 62-63; the control of the, in California, 99-101; swims river, 180.
  Sea, 38, 77, 177; notes on, 250-253; California, 252, 253.
  Steller, 251, 253.
Lizard, Alligator, 138.
  Fence, 138.
Lobster, 74, 75, 128.
  Spiny, 45, 71, 131, 273.
Lyon, Senator, 174.

M

Mack, A., 45.
Mackerel, 70, 108, 110, 130, 196, 219, 272.
  Frigate, 269.
Macneil, Hon. Hugh L., 84.
Maier, Simon, 83.
Mammal, 64, 151.
  Fur-bearing, 65.
Man, 128.
Map, 81, 97.
Marker, *see* Fish.
Marlin, 272.
Mather, Stephen T., 113.
McDaniel, Hon. Eugene P., 154.
McDougall, 60.
McIlhenny, Edward Avery, 65.
McKenzie, Fred, 47.
McLeod, Ranger Malcolm, 62.
Meadowlark, 81, 136.
Mice, Meadow, 138, 141, 142.
Migration, 4, 10, 18, 60, 65, 107, 114, 125, 126, 149, 253.
Migratory Bird Treaty Act, 44, 47, 66, 67, 162, 266.
Miller, Deputy B. H., 47.
Miller, J. O., antelope show increase, 128.
Milt, 55.
Mink, 118,
Mite, 128.
Mollusk, 59, 71, 112, 124, 131, 255, 273.
Moose, 47.
Morizio, Hon. Joseph, 84.
Morrison, Hon. J. M., 84.
Moss, 63.
Mountain lion, *see* Lion.
Mouse, 141.
Mudhen, 128.
Mullet, 70, 272.
Murdock, Hon. William C., 84.
Murrelet, 136.
Muskrat, 65, 116, 118; season closed in Minnesota, 185.
Mussel, 71, 112, 131, 273.

N

National Association of Audubon Societies, 118.
National forest, *see* Forest.
National Game Conference, the, 113-114.
National park, 82, 113, 118; municipal camps increase in, 163.
National park service, 262.
Natural History, San Diego Society of, 162.
Naturalist, 112, 270.
Nature guide, 113, 268.
Nest, 47.
Nesting ground, 115.
Net, 37, 38, 46, 48, 53, 56, 57, 58, 168, 175, 197, 224, 229, 230, 232, 234, 235, 236, 269; confiscated, 45.
  Bait, 220, 228.
  Crab, 175.
  Dip, 228, 234.
  Fyke, 175.

NET—Continued.
Gill, 7, 11, 125, 175, 196.
Japanese round-haul, 226.
Lampara, 196, 197, 224, 225, 226, 228, 235.
Purse, 175, 194.
Ring, 229.
Round-haul, 175, 221, 223, 224, 225, 227.
Salmon, 79.
Sardine, 217, 220, 223, 226, 227, 229, 230.
Shrimp, 77.
Trammel, 175, 219, 221, 222.
Newbert, Hon. F. M., 81, 84.
Newsome, Deputy, 168.
Nidever, H. B., black fish near Santa Catalina Island, 64.
Nielsen, E. M., 192.
Note, 22.
Commercial fishery, 54-58, 124-127, 174-177.
Hatchery, 49-53, 122-124, 169-173.
Life history, 62-64, 127, 180-184.
State fishery laboratory, 59-61, 177-180, 270.
Notoedres, 128.
Numenius hudsonicus, 181.
Nutria, 118.

O

Ober, Deputy E. H., 44.
O'Connell, Deputy, 168.
Officer, executive, 83.
Oil, 64, 106, 118.
Fish, 55.
O'Malley, Henry, 46.
Oncorhynchus nerka, 114.
Opossum, killed on Mount Hamilton, 62; seen in Pacheco Pass, 184; in Ventura County, 184.
Osprey, 141, 144, 145.
Organization, 87.
Owl, 133, 134.
Oyster, 74.
Eastern, 71, 131, 273.
Native, 71, 131, 273.

P

Pack, 106, 116.
Packer, 41.
Parcel post, 85, 86.
Park, National, *see* National.
State, 67.
Partridge, 66.
Hungarian, 80.
Patrol, 84.
Boat, *see* Boat.
Launch, 71.
Service, 77, 163.
Pearson, T. G., 118.
Pellet, 135.
Pelt, 116, 119.
Perch, 68, 70, 130, 266, 272.
Black, 270.
Blue, 270.
Glass-eyed, 74, 75.
Ring, 76.
Surf, 270.
White, 270.
Yellow, 74, 76.
Permit, scientific, 266.
Personnel, changes in, 59.
Pest, 134.
Phalarope, Red, 136.
Phanerodon atripes, 270.
Pheasant, 47, 80, 128.
Oregon, 79.
Ring-necked, 79.
Phoebe, Say, 136.
Phillips, John M., 65.
Phoedovius, Frank, 86.
Pigeon, 79, 85, 128, 271, 274.
Band-tailed, 262.
Pilchard, 193, 194, 205.
Pike, 70, 130, 272.
Pine, 25.
Plankton, 24.
Planting, 112, 113, 116, 126.
Plant, reduction, 124, 174, 207; by-products, 207.
Plover, Golden, 265.
Poison, 116, 119.
Pole, 24, 25, 26, 28, 29.
Bamboo, 25.
Pollution, 67, 76, 83.
Pomona College, 59.
Pompano, 70, 130, 272.
Porcupine as food, 127.
Postal law, *see* Law.
Poster, 46.
Post mortem, 128.
Poultry, 119, 137, 139, 141.
Food, *see* Food.
Powder, 85.
Prairie chicken, *see* Chicken.
Predatory, *see* Bird and Animal.
Preservation, 47, 53, 59, 74, 85, 116, 118.
Laboratory, 46, 256.
Propagation, 50, 52, 53, 57, 58, 80, 83, 84.
Protection, 47, 65, 66, 106, 111, 120, 128.

Q

Quail, 47, 66, 67, 68, 80, 81, 83, 85, 115, 128.
Chinese, 76.
Elegant, 76.
Mountain, 262.
Valley, 136.
Quarter-oils, or half-pound ovals, 106-110.
Quince, Judge, 48.

R

Rabbit, 66, 67, 68, 128, 138, 139.
Cottontail, 120, 138.
Jack, 47.
Brush, 138.
Rack, *see* Fish.
Radcliffe, Lewis, 46.
Rat Fish, 111.
Redding, Hon. B. B., 74, 84.
Redding, Hon. Joseph, 78, 84.
Reedbird, 47, 266.
Refuge, 166; fur-bearers protected in Trinity, 118.
Game, 44, 65, 66, 82, 100, 101, 113.
Wild life, 65.
Report, 44, 68-71, 114, 128-132, 186-187, 271-274.
Biennial, *see* Biennial.
Resort, Summer, 158; educational work, 1921, 262.
Requa, Ralph, 43.
Reservation, 65, 66, 116.

Rhacochilus taxotes, 270.
Rich, John W., 59.
Rich, Willis, 57; an instance of adult, sea-run Chinook salmon found feeding in fresh water, 7-8; the relative maturity of the Chinook salmon taken in the ocean along the Pacific Coast, 12-22.
Rig, 29, 31; plan of, 27-28.
Rigdon, Senator, 174.
Roccus lineatus, 76.
Rock bass, *see* Bass.
Rockfish, 70, 130, 270, 272.
Rod, 37.
Rodent, 119, 133, 134, 139, 142.
Roe, 55.
Rominger, Senator, 174.
Routier, Hon. Joseph, 78, 84.

S

Sablefish, 70, 130, 272.
Sage Hen, 68.
Sage, Mrs. Russell, 65.
Sale, 47, 83.
Salmo, clarkii, 10.
gairdnerii, 114.
irideus, 9, 10, 11, 114.
henshawi, 148.
regalis, 148, 149.
rivularis, 114.
smaragdus, 149.
shasta, 114.
Salmon, 9, 11, 34, 35, 36, 37, 38, 39, 44, 48, 55, 56, 57, 58, 59, 68, 70, 77, 78, 81, 84, 111, 116, 121, 123, 124, 125, 128, 130, 161, 175, 176, 207, 261, 270, 272; three California marked salmon recovered, 1-6; gear used for salmon trolling in California in 1920, 22-38; number, 42; of Klamath River threatened with extermination, 42; and trout distribution, 49; egg collecting, fall of 1919, 49-51; San Joaquin River, 51-52; in Eel River, 52-53; conservation and salmon trolling, 55-58; Eel River problems, 58; how many eggs does a salmon lay?, 63-64; destroyed on spawning beds, 114; Sacramento River salmon marking, 1920, 125-126.
Blueback, 114.
Chinook, 23, 37, 38, 42, 83, 112, 126, 163, 169, 170; an instance of adult, sea-run Chinook salmon found feeding in fresh water, 7-8; the relative maturity of the Chinook salmon taken in the ocean along the Pacific Coast, 12-22; in Lake Ontario, 162-163.
Chum, 117.
Eastern, 117.
King, 9, 10, 63, 126.
Klamathon, 63, 64.
Land-locked, 76.
Pacific, 54.
Quinnat, 58, 74.
Sacramento, 63.
Silver, 9, 23, 37, 38, 58.
Sockeye, 7.
Salmon culturist, 58.
Sanborn, Hon. F. G., 84.
Sanctuary, for wild life deeded to Louisiana, 65; Vermont establishes sanctuary for waterfowl, 65.
Sanddab, 70, 130, 272.
Sanders, J. H., 166.
Sandpiper, Pectoral, 265.
Sardina coerulea, 194, 219.
melanosticta, 194.
neopilchardus, 194.
ocellata, 194.
pilchardus pilchardus, 193, 194.
pilchardus sardina, 194.
sagax, 194.
Sardine, 23, 33, 34, 35, 59, 61, 70, 105, 107, 108, 116, 117, 124, 125, 130, 249, 261, 272; the future of the, 38-41; season, 59; conferences on the sardine work, 60; and whales, 110-111; the sardine of California, 193-194; historical review of California sardine industry, 195-206; fertilizer, stock food, and oil from sardine offal, 207-218; California, food products and their preparation, 238-247; number, 261-262; comparison of catch, 261-262.
Scabies, tree squirrels infested with, 128.
Scale, 2, 3, 4, 5, 6, 9, 10, 11, 12, 14, 15, 17, 18, 110, 114, 125, 126.
Scallop, 112, 273.
Schaeffle, Ernest, 83.
Sciaena thompsoni, 126.
Scientific assistant, 114.
Sciurus griseus griseus, 128.
Scofield, N. B., 77, 178, 269; commercial fishery notes, 54-58, 124-127, 174-177.
Scofield, W. L., 1, 42, 55, 59, 60, 269; gear used for salmon trolling in California in 1920, 22-38; a further note on the Monterey gulls, 61; hunting the wild boar in central France, 102; Sacramento River salmon marking, 1920, 125-126; fertilizer, stockfood and oil from sardine offal, 207-218.
Scott, Senator, 175.
Screen, *see* Fish.
Sculpin, 70, 130, 272.
Sea bass, *see* Bass.
Sea elephant, near San Clemente, 267.
Sea lion, *see* Lion.
Seal, 38, 177.
Fur, 253.
Leopard, 252.
Search, 68, 128.
Season, 47, 59, 106, 112, 113, 114, 117, 119, 121, 124, 175; more fines for hunting out of, 115; prospects, 122-124.
Open, 175, 264.
Sea trout, *see* Trout.
Seaweed, 176.
Sebastodes
atrovirens, 270.
chlorostictus, 270.
eos, 270.
gilli, 270.
goodei, 270.
introniger, 270.
levis, 270.

Sebastodes—Continued.
mineatus, 270.
ovalis, 270.
paucispinis, 270.
rastrelliger, 270.
serranoides, 270.
Seine, 11, 19.
Beach, 14, 16, 17, 20, 175.
Purse, 12, 221.
Seining, 52, 55.
Seizure, 44, 68, 128, 186.
Sette, O. E., 59, 60, 178, 269; rare fish taken at San Pedro, 270.
Seybold, A. P., 42.
Shad, 70, 75, 76, 77, 131, 175, 272.
Buck, 70, 131, 272.
Roe, 71, 272.
Shark, 38, 213, 252; basking, at Monterey, 178.
Shearwater, 232, 252.
Shebley, W. H., 2, 43, 74, 83; hatchery notes, 49-53, 122-124, 169-173.
Sheephead, 71, 131, 272.
Sherwood, Hon. T. J., 84.
Shook, Frank, 113.
Shooting, 63, 64, 67, 115; ground, public, 66, 67, 161, 263-264.
Shotgun, 102.
Shrimp, 68, 71, 131, 175, 273.
Sinker, 30, 31.
Canoe, 30.
Round, 30.
Torpedo, 30.
Skate, 71, 131, 273.
Skipjack, 71, 131, 273.
Skin, 65, 116, 118, 119, 128.
Skogsberg, Tage, 269.
Skunk, 65, 119, 141, 182, 183.
Smelt, 7, 8, 71, 128, 131, 231, 273.
Surf, 269.
Snail, 131, 273.
Snake, water, 53.
Striped racer, 138.
Gopher, 138.
Snyder, J. O., 10, 42, 161; three California marked salmon recovered, 1-6; steelheads caught at sea off the coast near Fort Bragg, 9-11; how many eggs does a salmon lay?, 63-64.
Sole, 71, 124, 131, 273.
Sparrow, 136.
Spaulding, M. K., 82.
Spawn, 51, 53, 58, 125, 171.
Spawning, 8, 10, 12, 14, 18, 22, 39, 42, 50, 51, 53, 56, 57, 79, 103, 105, 106, 108, 109, 110.
Bed, 114.
Ground, 53.
Spear, 50, 114.
Spilopelia chinensis, 180.
Spinner, 11, 84.
Spiny lobster, *see* Lobster.
Splittail, 71, 131, 273.
Spoon, 25, 28, 31, 32, 33, 34, 36, 37, 38.
Diamond, 33, 35.
Dubrow, 34, 35.
Home-made, 33, 34.
Kewell-Stewart, 33, 34, 35.
McMahon, 33, 34, 35.
Salmon, 33, 34.
Stewart, 34.
Wilson, 33, 34.
Sportsmen, 47, 58, 66, 81, 84, 115, 116, 127, 160, 161, 181; and anglers' organizations, 44; Lake County, organize, 161.
Sprat, 193, 195, 199.
Squab, *see* Dove.
Squid, 23, 33, 71, 111, 124, 131, 213, 273.
Squirrel, 128, 182.
California Grey, 128.
Ground, 133, 137, 138, 139.
Tree, infested with scabies, 128.
Stanford University, 1, 9, 16, 59, 64, 81, 103, 112, 159, 161.
Starks, E. C., 112, 194; notes on the sea lions, 250-253.
State Board of Examiners, 78.
State Department of Printing, 87.
State Fair, Exhibit, 177; 1921, 262-263, 268.
State Fisheries Laboratory, new, 150-153, 152, 177.
Station, Egg Collecting, 52, 53, 57, 76, 83, 122, 123, 170.
Battle Creek, 50.
Bogus Creek, 170.
Domingo Springs, 124, 171, 172.
Experimental, 52.
Feather River, 170.
Hornbrook, 123, 170.
Klamath River, 123.
Mill Creek, 50, 126.
North Creek, 124.
Rae Lakes, 170.
San Joaquin River, Experimental, 124.
Scott Creek, 123, 124, 170.
Snow Mountain, 123, 170, 171.
Warner Creek, 172.
Steelhead, *see* Trout.
Stereopticon Slide, 44.
Stevens, Assemblyman, 176.
Stingaree, 71, 131, 273.
Stinnett, L. J., 50.
Stone, Hon. George, 84.
Stone, Livingston, 74, 75.
Stoner, Emerson A., 264.
Striped bass, *see* Bass.
Sturgeon, 77, 79.
Subject, finding list of, *see* Finding list.
Sucker, 131, 141, 273.
Sunfish, Blue-gilled, 76.
Supervisor, 113.
Board of, 128.
Superior Court, *see* Court.
Supreme Court, *see* Court.
Surf-fish, 273.
Surfsmelt, the, *hypomesus*, 270.
Survey, Biological, *see* U. S. Bureau of.
Swallow, Barn, 265.
Swan, 128.
Swordfish, 71, 131, 273.

T

Tahoe Camping Ground, 69, 132.
Tank, 74.
Tautog, 74, 75.
Teachers' Bulletin, *see* Bulletin.
Teal, Blue-winged, 167.
Teredo, 46.
Terrapin, 273.
Thaleichthys pacificus, 7.
Thompson, Will F., 81, 126, 178, 179, 254, 255, 269; the future of the sardine, 38-41; quarter-oils or half-pound ovals, 106-110; whales and sardines, 110-111; State Fisheries Laboratory, 150-153; notes from the State Fisheries Laboratory, 59-61, 177-180, 269; library for the new laboratory, 178; basking shark at Monterey, 178; rag fish at Monterey, 179; the sardine of California, 193-194; historical review of California sardine industry, 195-206.
Thread, Airplane, 36.
  Irish flax salmon, 36.
  Liner, 36.
Throckmorton, S. R., 74, 84.
Tomcod, 71, 131, 273.
Track, 180.
Transportation, 52, 83, 85.
Trap, 17, 20, 38, 53, 114, 116, 193.
  Crab, 175.
  Duck, 167.
Trapper, 46, 116; experiences of, 182-184.
Trapping, 46, 65, 116, 118.
  Season, 119.
Trawling, 121.
Tree, 118, 128.
Tressler, Donald K., 54, 55.
Troll, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22.
Trolling, 8, 24, 25, 26, 28, 31, 38, 53, 58; gear used in California in 1920 for salmon, 22-38; salmon conservation and salmon, 55-58.
Trough, 125, 126.
Trout, 10, 44, 68, 81, 83, 84, 113, 128, 268; and salmon distribution, 49.
  Black-spotted, 169, 170.
  Brook, 74.
  Brown, 169, 266.
  Cutthroat, 10.
  Eastern Brook, 113, 169.
  Farm, 273.
  Golden, 44, 76, 84, 266, 268.
  Loch Leven, 44, 112, 124, 169.
  Rainbow, 9, 11, 113, 114, 122, 123, 169, 170, 171, 266; in Hawaii, 116; acclimatized in Australia, 265-266.
  Royal Silver caught in Lake Tahoe, 148.
  Sea, 70, 130, 272.
  Silver, 149.
  Steelhead, 8, 42, 53, 58, 71, 123, 124, 131, 149, 169, 170, 171, 273; caught at sea off the coast near Fort Bragg, 9-11; distinct species, 114.
  Tahoe, 75, 148, 149.
  Truckee, 149.
Trichiurus lepturus, 179.
Truckee Lumber Company, 85.
Tuna, 71, 106, 108, 110, 111, 116, 125, 127, 131, 219, 221, 249, 261, 273.
  Bluefin, 71, 131, 269, 273.
  Yellowfin, 71, 131, 269, 273.
Turbot, 71, 131, 273.
Turkey, wild, 47, 80.
Turnstone, black, 136.
Turtle, 71, 273.

U

United States Bureau of Biological Survey, 47, 65, 67, 115, 118, 136, 137, 139, 140, 166, 167.
United States Bureau of Fisheries, 2, 7, 12, 43, 46, 49, 50, 51, 54, 56, 75, 114, 116, 126, 162, 178, 256, 262.
United States Bureau of Fisheries Preservation Laboratory, 55.
United States Commission of Fish and Fisheries, 74.
United States Department of Agriculture, 47, 115, 141, 142, 163, 164, 166, 167, 218, 266, 267.
  Yearbook, 116.
United States Food Administration, 249.
United States Forest Service, 49, 185.
United States Postal Service, 43.
United States Supreme Court, *see* Court.
University of California, 74, 81, 128.
  Michigan, 126.
  Oregon, 59.

V

Van Arsdale, Hon. W. W., 84.
Van Sicklen, Hon. F. W., 84.
Van Valkenburg, Federal Judge, 115.
Venison, 83.
Veterinary, 128.
Violation, 42, 83, 105, 115; of fish and game law, 45, 48, 68, 129, 186.
Violator, 113, 114, 268.
  Hunting, 66.
Vogelsang, C. A., 83.
Vogelsang, Hon. Alex. T., 84.
Vulture, 135.
  Turkey, 143, 146.
  California, 143, 146.
Von Arks, Deputy, 168.

W

Wagner, H. Otto, 163.
Walters, C. J., 113.
Ward, Charles Willis, 65.
Warden, *see* Fish and Game.
Water, 118.
Waterfowl, 67, 136, 166, 266; Vermont establishes sanctuary for, 65; trapping, allowed in England, 161.
Waterman, Hon. R. W., 77.
Weir, 193, 195, 266.
Weight, 25, 27.
Wells, A. W., some considerations concerning the salting of fish, 54-55.

Westerfeld, Carl, 83, 84, 123.
Wetmore, Alexander, 265.
Weymouth, F. W., 16, 59, 60, 81, 112; the abundance of young Pismo clams, 103-106.
Whale, 177, 213, 262; and sardines, 110-111.
Whitebait, 131, 273.
Whitefish, 71, 131, 273.
Why?, 45.
Wildfowl, 113, 167; need protection and feeding grounds, 166.
Wild life, 42, 44, 66, 73, 81; sanctuary deeded to Louisiana for, 65.
Conservation, 81; President Harding in sympathy with, 118.
Film, 44.
Wilson, Hon. Ramon E., 84.
Wolf, timber, 183.
Woodbury, J. G., 74.
Woodcock, 266.
Wood duck, *see* Duck
Wulff, J. V., albino deer seen in Stanislaus forest, 182.
Wright, W. H., opossum killed on Mount Hamilton, 62.
Wyman, L. E., introduced dove thrives in Los Angeles, 180.

Y

Yearling, 6, 8.
Yellowtail, 71, 124, 131, 273.
Yosemite Nature Guide Service, 262.

Z

Zirn, H., 45.

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